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DESIGNING A CELL PHONE APPLICATION TO ALERT AND REPORT DRINKING WATER QUALITY TO SOUTH AFRICANS

by

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Thesis submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Information Technology

Rochester Institute of Technology

B. Thomas Golisano College of

Computing and Information Sciences

Department of Information Technology

08/19/2009

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ABSTRACT

Drinking water quality, especially in many parts of South Africa, is far below acceptable standards. With an annual estimate of 43, 000 deaths from diarrheal diseases, 3 million cases of illness and treatment costs of over half a billion US dollars, the impact is critical (Mackintosh & Colvin, 2003).

To address this issue the Aquatest project seeks to develop a simplified low-cost water quality test kit and information management solution. This would allow Water Service Providers, especially in rural areas, to monitor water quality and distribute test data to the necessary parties - Water Service Authorities and consumers.

This research addresses the challenge of reporting complex and critical water quality information in a way that is accessible to all South Africans as law requires. In a country with high illiteracy rates, 11 official languages and limited-to-no access to technology in many areas, this is no easy feat. We propose that the use of appropriate information and communication technologies (ICT), coupled with culturally appropriate ways of presenting scientific data, would allow water quality information to be accessible to South Africans.

With the penetration level of cell phones exceeding 100% of the South African population (ITU, 2008), the low cost of Mobile Internet access and the popularity of cell phone applications such as Mxit used for social networking, mobile technology seemed promising. This led to the design of *Water Alert!*, a cell phone application that alerts and reports critical water quality information to consumers who subscribe to it. Our assessment and evaluation of this design with users suggested that such an application would help to improve the consumers' level of understanding of water quality information since the use of a tool and interface design that they are familiar with would lower the learning curve, while symbol-based messages would make critical water quality information more accessible to all regardless of their literacy level or language spoken.

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1. INTRODUCTION

1.1 RESEARCH TOPIC

My research topic is designing a cell phone application to alert and report drinking water quality to South Africans.

1.2 STATEMENT OF THE PROBLEM

UNSAFE DRINKING WATER

Safe drinking water is 'a source of life' (Mackintosh et al., 2005). The antithesis, however, is a major contributor to the 1.8 million people dying per year from diarrheal diseases, with over 40,000 of whom are South Africans (Mackintosh & Colvin, 2003). Diarrhea is a major killer among communicable diseases, preceded only by respiratory infections and HIV/AIDS (WHO, 2008). In South Africa, children and immunocompromised individuals comprise a sizeable portion of the population who are most susceptible to water-borne diseases found in contaminated water. For these individuals, safe drinking water *is* life.

Monitoring water quality and comparing it to the national drinking water quality standards play a vital role in reducing the high number of deaths caused from ingesting contaminated drinking water. However, these are only two of three protective measures required by the 1997 Water Services Act and the *Compulsory National Standards for the Quality of Potable Water* (Mackintosh et al., 2005). Communicating water quality test results to consumers and to water authorities is critical also.

AQUATEST: THE SOLUTION

The Aquatest project, currently funded by the Bill and Melinda Gates Foundation (previously by the European Union) and spearheaded by the University of Bristol, seeks to address these legal requirements by developing a low-cost water quality test kit to be used by both water professionals and the general public in developing countries to test and monitor water quality. It also seeks an information management solution, allowing for easy collection and management of water quality data gathered from testing.

THE CHALLENGE: COMMUNICATING WATER QUALITY DATA TO CONSUMERS

Outside urban areas in South Africa, failure to intervene and communicate to consumers the detection of contaminated drinking water and the corrective measures to take is one reason so many people contract water-borne diseases. Water Service Providers (WSP) currently collect and communicate results to Water Service Authorities (WSA), but there are few, if any, measures in place for WSPs to get this information out to consumers. The main concern WSPs have with implementing a communication channel is in identifying the appropriate medium for disseminating water quality information to consumers given the existing technological constraints. In a country with eleven official languages and a large illiterate and semi-illiterate population, how do you present water quality data in a way that is easily understood by all? Bridging the gap in communicating water quality information from 'catchment to consumer' (as Mackintosh et al. terms it) to address these concerns forms the basis of this research. A fulfillment of this would be a fulfillment of the aforementioned Water Service Act of 1997, which states consumers must be informed about water-quality testing results in a manner they can easily understand. Additionally, providing this information is paramount to enabling consumers to enforce their rights.

Information and communication technologies are explored to find appropriate means of disseminating water quality information to consumers. In particular, we explore the use of symbol-based messages sent via a cell phone application and/or MMS text messages due to the availability and widespread popularity of these technologies in South Africa. Selected user-centered design techniques, tailored for developing world design projects, are also used to guide the design of a symbol-based water alert prototype application WSPs can populate and use to easily disseminate current Water Quality Reports and alerts to consumers.

1.3 HYPOTHESIS

To communicate drinking-water quality information to consumers in the South African community, the use of appropriate Information and communication technologies (ICT) (such as a cell phone application and text messaging), coupled with culturally-appropriate ways of presenting scientific information, increase the consumer's access to and interpretation of water quality test data, leading to an improved Community Perspective on drinking water quality as required by law.

1.4 AREAS OF INVESTIGATION

- The appropriateness of cell phones as a means of disseminating water quality information to South African consumers.
- An analysis of signs and symbols in the Cape Town region, which form the basis of a standardization of symbol-based messages presenting water quality information to the general public.
- Transformation of a scientific paper-based Water Quality Report into a simplified and accessible symbol-based report to be disseminated to consumers via cell phones.
- Appropriate user-centered design techniques to employ for a developing world design project.

1.5 OVERVIEW OF METHODOLOGY

This project followed a hybrid of Contextual Design (CD) techniques and Scenario-Based Development (SBD) techniques. Contextual design techniques, such as contextual inquiry and work modeling, were chosen based on the success seen by Maunder and others in employing these techniques in developing world design contexts (Maunder et al., 2007). Scenario-based development techniques such as metaphors were employed to guide activity, information and interaction design of the cell phone application. Prototyping and user evaluation were done successively in multiple iterations. Both low-level paper prototypes and high-level flash prototypes were utilized to convey design decisions. Formative evaluation was done to guide redesign, while summative evaluation in the form of a water quality comprehension test was done to test the hypothesis.

Our project is broken into the three phases of SBD:

- Requirements Analysis
- Design and Prototyping
- Evaluation

We anticipated two user groups, which we profile in the Requirements Analysis section: the General Public and Advanced Users such as health professionals and community leaders.

2. REQUIREMENTS ANALYSIS

Requirements Analysis is the process during which the users' needs and expectations of a new or redesigned product or service are determined (Rosson et al., 2002). Requirements Analysis in user-centered design is an ongoing process as opposed to a one-time occurrence as is the case in the waterfall model often used in software engineering.

2.1 CONTEXTUAL INQUIRY

Contextual design, which is “essentially a fusion of user-centered design and ethnographic principles” (Maunder et al., 2007) is great to use in developing world design since it places emphasis on understanding the user and the user's context. *Contextual Inquiry*, in particular, is a technique designed to “reveal all aspects of work practice” by observing and spending time with customers in their context (Beyer et al., 1998).

This “field data-gathering technique” (Beyer et al., 1998) was employed in this project to understand how South African residents generally access information, how they obtain information on drinking water quality and their preferences for a solution to accessing water quality information. We also assessed their familiarity with and attitude towards cell phone applications and SMS/MMS text messaging. A total of twelve people responded to our questionnaire with three individuals interviewed as discussed below.

QUESTIONNAIRES

A questionnaire was drafted to issue to randomly selected consumers 18 years of age and older. Early findings revealed that simply issuing questionnaires to individuals to complete on their own was not going to be effective for the following reasons:

- The length of the questionnaire required more time than most people were willing to spend on a questionnaire.
- The front page, which asked general information such as a classification of the area in which you live and educational level, was intimidating to potential participants. After glancing through the questionnaire, they opted not to complete it. Once this page was flipped to the back, however, people were less hesitant to complete it.

- Some of those who opted to complete the questionnaire required an explanation of the rating system used and certain terminologies such as ‘purification’. Such constant guidance was taxing on the researcher’s time and cumbersome when multiple people were completing the questionnaire simultaneously.

As a result, we went through the questionnaire with each participant and recorded their responses on the questionnaire. This proved to be a more successful approach to collecting qualitative data, but conversely more time consuming, taking between 20 – 40 minutes to complete each one. Ultimately, we only collected responses from twelve individuals due to the amount of time required to issue the questionnaire and the purpose of the questionnaire being to guide design.

INTERVIEWS

Three interviews were conducted with members of the target group. Participants were asked questions identical to those on the questionnaire and then observed performing various tasks on their cell phones, such as sending an SMS/MMS message, using the voice recorder, ‘missed-calling’ a number, accessing MXit (a social networking application), or using a calendar application. They also discussed how they were currently informed about water quality information (if at all) and explained how they determined whether the water was safe enough to drink.

FINDINGS

A combination of the responses from the twelve people who responded to the questionnaires and the three people interviewed formed the basis of the work models and scenarios that follow in the Requirements Analysis Phase.

2.2 STAKEHOLDER PROFILE

THE GENERAL PUBLIC

This includes anyone living or residing in South Africa (18 years and older), since everyone has a right to access water quality information. This group consists of a wide array of individuals with different levels of exposure to technology, varied literacy levels and non-English speakers. The majority have little-to-no experience with interpreting water quality test results. The majority of them own or have access to cell phones and would like an easy-to-use application to receive alerts about their water quality.

HEALTH PROFESSIONALS/LEADERS

This group includes nurses, community leaders, or others who may serve as conduits to disseminate water quality information to the general public. They have a moderate level of exposure to technology and a moderate-to-high understanding of water quality test results and water purification techniques. They want an application that provides advanced information about water test results but in a manner that is still easy to access and understand.

2.3 WORK MODELING

CONSOLIDATED FLOW MODEL

The flow model reveals three key players in the dissemination of water quality information as shown in the Consolidated Flow Model in Figure 2-1.

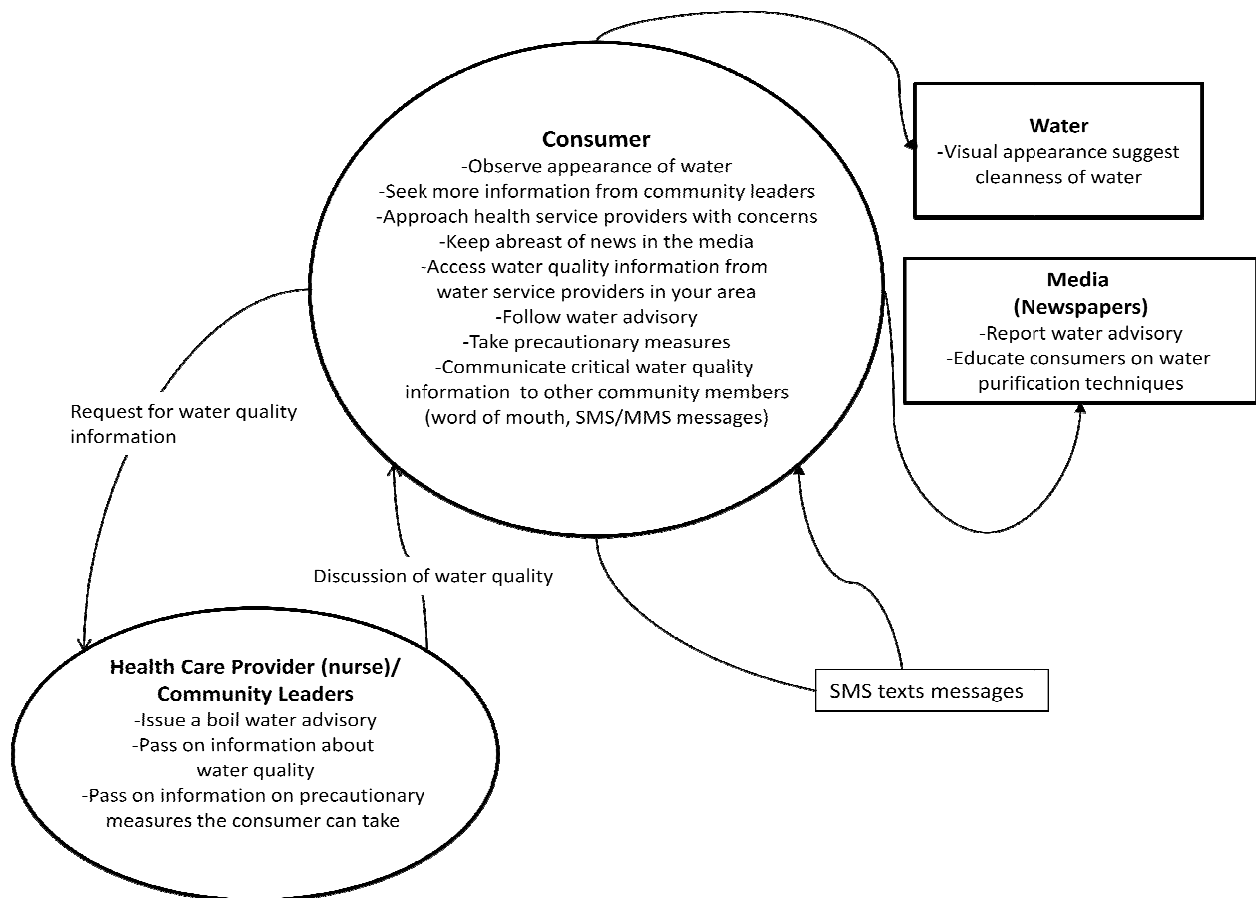


Figure 2-1. Consolidated Flow Model

- *Health Care Providers (such as nurses) and Community Leaders* - These individuals are well-respected figures in the community and a reliable source of water quality information for consumers. They issue boil water advisories as well as educate community members on water purification techniques and precautions to take. They convey water quality information requested by consumers or when informed of issues by the water service provider or the media.
- *The Consumers/Community Members* - The consumer obtains water quality information through the media, health professionals, community members and leaders in critical situations or upon request in cases when they are experiencing illness or when they have observed water of a poor physical quality such as cloudy water with particles. *Community members* are consumers living in the same community. They keep each other informed by spreading critical water quality information virally by word-of-mouth and through SMS text messages.

CONSOLIDATED SEQUENCE MODEL

“An intent is stable” and an understanding of a user’s intent is essential to the design process (Beyer et al., 1998). Sequence models reveal triggers and the underlying intents of users when performing a series of actions, collectively termed *work*. For this reason, *sequence modeling* - a contextual design technique, was chosen over Task Analysis used in Scenario Based Design (SBD). Below is the Consolidated Sequence Model based on responses collected from three interviewees. Consumers typically obtain water quality information following a four-part sequence as shown below. The individual sequence model for each interviewee can be found in Appendix B.

Table 2-1. Water Quality Information

| Activity | Intent | Abstract Step |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Find reason for problem (dirty tap water, illness) | <ul style="list-style-type: none"> • Determine course of action • Find solutions • Resolve the problem | <ul style="list-style-type: none"> • Trigger: To find reason for problem - poor quality water coming from tap - people get sick |
| Seek out reliable information source | <ul style="list-style-type: none"> • Get water advisory • Voice concerns | <ul style="list-style-type: none"> • Approach community leader to find out about water quality • Go to healthcare provider • Tap into media to receive current information on water quality • Discuss water quality concerns with community members |
| Get advice | <ul style="list-style-type: none"> • Be informed about precautionary measures to take • Learn how to help children recover | <ul style="list-style-type: none"> • Request advice • Listen to or read water quality advisory |
| Follow advice | <ul style="list-style-type: none"> • To protect health • Get healthy • Prevent further problems | <ul style="list-style-type: none"> • Purify water • Refrain from drinking water • Go elsewhere to use water |

CONSOLIDATED CULTURAL MODEL

According to Beyer and Holtzblatt, people's actions are highly influenced by the culture in which they live (Beyer et al., 1998). The cultural model in Figure 2-2 shows how water service providers take advantage of the South African community culture of 'viral communication' as a means of disseminating information. They provide information to conduits such as the media, health providers and community leaders with the expectation that this information is passed on to consumers. This, of course, is only done when critical. We observe that with this culture, consumers seldom go directly to Water Service Providers to obtain water quality information. Moreover, the water quality paper reports provided by the WSPs are so complex that conduits such as health service providers and the media are needed to put it into simpler terms.

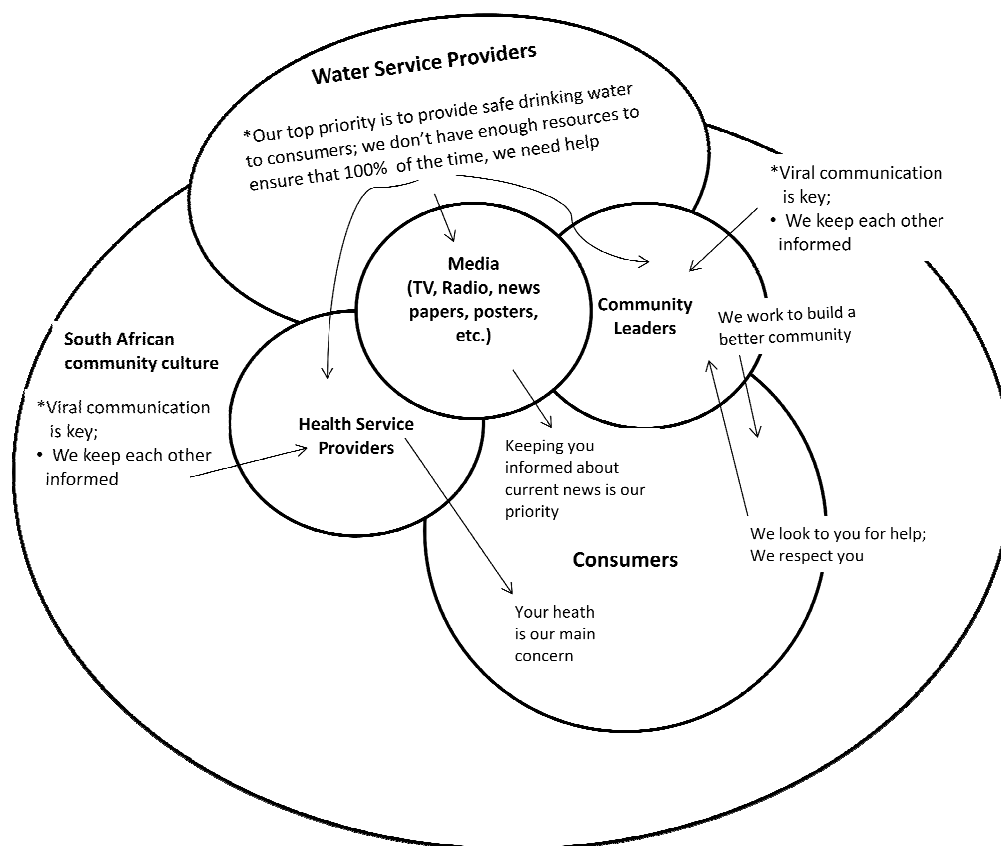


Figure 2-2. Consolidated Cultural Model

ARTIFACT MODELS

We observed and interacted with some of the cell phones of our participants, the model used in our research, as well as other models used in South Africa to get an idea as to the features available across models and the applications that were being used.

2.4 HYPOTHETICAL STAKEHOLDER PROFILE

Limpho is a woman in her early thirties who lives in Mandalay with her husband and three children. She is a hairdresser by occupation who works on and off when clients are available. She spends a lot of her time at home cooking, cleaning and taking care of her young children. She makes a couple trips back and forth to the community standpipe to gather water for her family to drink and for other household uses. Her family does not own a television but occasionally watches her neighbor's television. Limpho owns a cell phone, which she bought in Cape Town, and uses it to text her relatives and friends. She has never used a computer, and does not realize she is accessing the Internet when she goes on the MXit chat room on her phone, which she enjoys doing. Limpho speaks English, Xhosa and Zulu.

Tsebo is the head nurse at the Mandalay public clinic. She has worked there for over thirty years and is a resident in the area as well. She has delivered many babies in the community and is sought after for medical advice. Tsebo received an Associate's degree from a local college and has completed a computer course. She is responsible for all the computer-related tasks at the clinic and is the only one who knows how to use the Internet. Tsebo often does research on the Internet to learn about new diseases and to keep informed. She listens to the radio and watches television. She educates her patients about their illnesses along with ways of living healthy lives.

Mamello is a well-respected member of the Mandalay community. He has served as the community leader for over twenty years. He holds a Bachelor's degree in Economics from the University of Cape Town and has worked in various political positions. He is amicable and wellspoken, with community members approaching him to voice their concerns, which he in

turn voices to the mayor. Mamello keeps the community informed in times of crisis, such as when the Water Service Provider informs him water is contaminated.

2.5 PROBLEM SCENARIO

LIMPHO SEEKS TREATMENT FOR CHILDREN'S ILLNESS FROM TSEBO

Limpho's children are all ill with diarrhea. She goes to the local clinic to see Tsebo to find out what could be the cause. Tsebo suspects the water is to blame as she has seen an increase in the number of reports about patients with diarrhea and high fever. She goes to the local Water Service Provider and asks them about the quality of the water. They tell her they recently had a health failure due to high E. coli levels found in the water and are urgently working to correct the issue. They tell her to inform her patients and tell them not to drink the water from the tap. She returns to the clinic where she later advises Limpho to boil the water from the tap before using it, as it is the cause of her children's illness.

3. DESIGN

We chose to utilize activity, information and interaction design from Scenario-Based Design since it places stronger emphasis on the use of visual metaphors than the visioning phase of Contextual Design. Visual metaphors help the user to make meaning of information when there are similarities between the design and a familiar object. This is especially important for our target audience in the developing world who may have limited access to technology but own a cell phone and are intimately familiar with various applications on it such as text messaging and a calendar organizer. We assume that making use of such visual metaphors would not only contribute to the effectiveness of the application but would also empower instead of intimidate end users.

3.1 ACTIVITY DESIGN

CONCEPTUAL METAPHORS

ACTIVITY: Getting advice is like getting access to...

METAPHOR: MXit (a popular social networking application for cell phones developed in South Africa)

DESIGN IMPLICATIONS

- Download to phone
- Requires registration using cell phone number
- Tailored to show information specific to each user

3.2 INFORMATION DESIGN

PRESENTATION METAPHORS

ACTIVITY: Advisory and advice looks like an ...

METAPHOR: MMS text message

DESIGN IMPLICATIONS

- A mix of multimedia objects (images, rich text, audio, video)
- Short phrases with as few words as possible

ACTIVITY: Water quality report looks like a...

METAPHOR: Calendar organizer on cell phone

DESIGN IMPLICATIONS

- Month, year, dates and days of the week
- Dates with entries have a different color
- Dates for previous month faded
- Current selection highlighted

ACTIVITY: Subscription page looks like...

METAPHOR: Create a text message

DESIGN IMPLICATIONS

- Text fields to enter phone number and insert text
- Labels for text fields
- Quick to fill

3.3 INTERACTION DESIGN

PRESENTATION METAPHORS

ACTIVITY: Browsing the Water Quality Report is like...

METAPHOR: Calendar organizer on cell phone

DESIGN IMPLICATIONS

- Press left and right keys to change current month/year when selected
- Use four-way navigation to get to a specific day of the month
- Press Enter/Select key to view entry for a chosen day
- Use left and right keys to navigate through entries for the date selected

ACTIVITY: Subscribing to the service is like...

METAPHOR: Composing a text message

DESIGN IMPLICATIONS

- Use up/down button to navigate between text fields
- Select text field and use keypad to enter text
- Submit when done

At the end of the design phase, we capture the design decisions in a storyboard. We use storyboards from Contextual Design over design scenarios in SBD since it is a more graphical representation of the proposed system design. This makes it easy for all users to understand our proposed system since it's visual rather than text heavy.

4. PROTOTYPING

Low-fidelity prototypes are quick, low-cost ways of evaluating and communicating various design concepts. However, they do not provide as much detail as high-fidelity prototypes. Based on Maunder's findings (Maunder et al., 2007), they may prove useless as a design tool for developing world projects, since subjects may not understand the purpose of a prototype and evaluate it as the real product. As a result, we used low-level prototypes in the form of paper prototypes mainly to evaluate the still symbol-based messages, which had no interactive elements.

High-fidelity prototypes, on the other hand, are costly and time-consuming to develop but provide the user with a more detailed and interactive view of the proposed system. These prototypes are great for conducting early usability testing and in evaluating key functionality. There is still, of course, the possibility that users could confuse a high-fidelity prototype for the final product. We used Adobe Flash Lite, a lighter version of Adobe Flash Player, as our high-level prototyping tool. This tool allowed for creating an interactive prototype for the Flash-enabled Nokia 3110 cell phone, which we used during the evaluation phase.

4.1 ANALYZING SYMBOLS IN THE CAPE TOWN REGION

Before we jumped into developing prototypes of the symbol-based messages, we decided to investigate the kinds of symbols appearing in and around the Cape Town region. We were interested in answering the following questions:

- What symbols are used to issue warnings/bans, caution and general information?
- Are there similarities with symbols falling into those three categories (e.g., colors, repeating symbol)?
- Are the symbols known by locals?
- Is text present? Is it translated to non-English languages?

An analysis of eighty seven photos taken of signs around Cape Town provided a collection of universally-known symbols and a color palette we adopted in the design of our prototypes.



Figure 4-1A. Categorized Snapshots of Symbols Taken Around Cape Town

From the symbols we saw recurring patterns for each of the categories we anticipate using in our application.

Warnings/bans: Red/black circle-slash over object; minimal/no text; white/amber background

Caution: Amber triangle with black border; cross symbol for health caution signs; numbers and pictures instead of text

Informational: Green background, white text; checkmarks affirm correct procedures; arrows show motion

In Figure 4-1B below, we show a snapshot of how these symbols helped to influence the design of the messages in our water quality application. We discuss the designs further in Section 4.2.



Figure 4-1B. Snapshots Guide the Design of Symbol-based Water Alert Messages

4.2 DESIGNING SYMBOL-BASED MESSAGES

We used paper prototypes followed by high-fidelity Flash Lite prototypes to evaluate the user's understanding of the symbol-based signs we created for communicating the current water quality status and for issuing (boil) water advisories. We found that for paper prototypes, the absence of color allowed the user to focus more on interpreting the drawing, whereas their responses were mostly related to the colors used in the Flash Lite prototype. We found this to be an appropriate balance to ensure a more thorough evaluation of both image and color. Below we highlight the results of the evaluation performed after each design iteration.

PAPER PROTOTYPE

With the help of the paper prototypes in Figures 4-2A and 4-2B, we were able to determine early in the study whether South Africans could understand culturally specific symbol-based alerts such as ‘do not drink tap water’. We did not spend a lot of time drawing sketches and evaluating them, as we know based on the experience of others mentioned earlier that higher level prototypes work better. Figure 4-2A shows a glass being filled with water. The speckles in the water depict that it is contaminated. The superimposed red circle-slash prohibition sign completes the full meaning, “Do not drink tap water”.

Figure 4-2B was designed after evaluating the graphic in Figure 4-2A. It depicted a person drinking water with a modified prohibition sign with two diagonals forming an ‘X’ instead of one diagonal as in the first version.

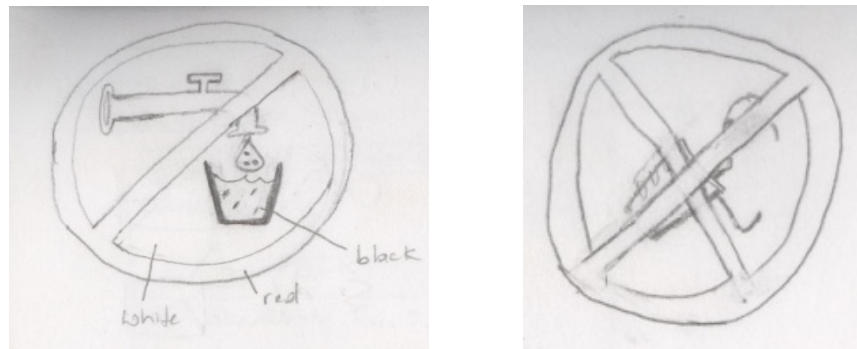


Figure 4-2a-b. Paper Prototypes of the Symbol-based Signs

FINDINGS AND EVALUATION

We showed these text-free drawings to three individuals and asked them to give their interpretation of the message in the picture. Both drawings were designed to alert consumers not to drink their tap water. Figure 4-2A was designed and evaluated first and evolved into Figure 4-2B based on the users' feedback. The first participant said the image in Figure 4-2A meant that the water supply had been cut off. She mentioned, however, that she could not understand why 'those black spots' are in the water. When asked how she arrived at her interpretation, she noted the diagonal slash cutting through the pipe meant water supply was cut off, which further explained why there was only one drop of water left and we see it falling into the bucket. The second person said it meant do not catch water from this pipe.

FLASH LITE PROTOTYPE 1

Based on the findings of the paper prototypes, we made adjustments to the drawing before creating the high-level Flash Lite version. For instance, we added a hand to the original drawing to depict that someone is filling a cup of water, not a bucket as one of the users originally thought. We also included color and more details in the Flash prototypes.

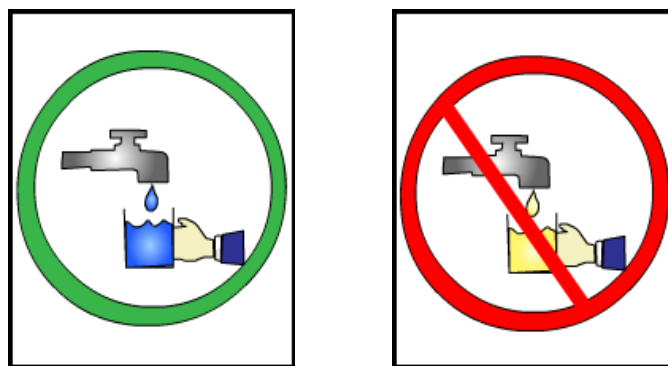


Figure 4-3a-b. Flash Lite Prototypes of the Symbol-based Picture Message

FINDINGS AND EVALUATION

We evaluated the designs with two new participants, since the previous participants were already told what the picture messages were supposed to convey. We found that for both images, the participants had a correct interpretation of the actions but did not grasp the message in its entirety. They interpreted the image on the right, which meant ‘Do not drink contaminated tap water’ as ‘do not catch water from the tap’. With the sign on the left, however, they both understood that someone was catching a glass of tap water, but they did not decipher the full message “Safe drinking water”. This was expected since we did not reveal the context of our messages to them until afterwards to prevent biased feedback. We noticed with this version that the use of multiple colors and detail distracted the participants. One reported that she did not understand why there was a green ring around the image and suggested that a prettier color be used, indicating that she missed the traffic-light representation of the green circle. Once we revealed to them, however, that the messages would form a part of a water-alert phone application, they agreed that knowledge of the context would have made it easier for them to interpret our symbol-based messages. One of the participants then suggested the use of a person drinking instead of a hand holding a cup to convey the ‘do not drink contaminated tap water’ message.

FLASH LITE PROTOTYPE 2

In version two of the Flash Lite prototypes, we abstracted the images and used fewer colors to prevent distracting users from the true meaning. In addition, following the participants’ advice, we changed the image of the hand holding a cup to that of a person drinking from the cup. We made both a text-free version and a version with text to evaluate.

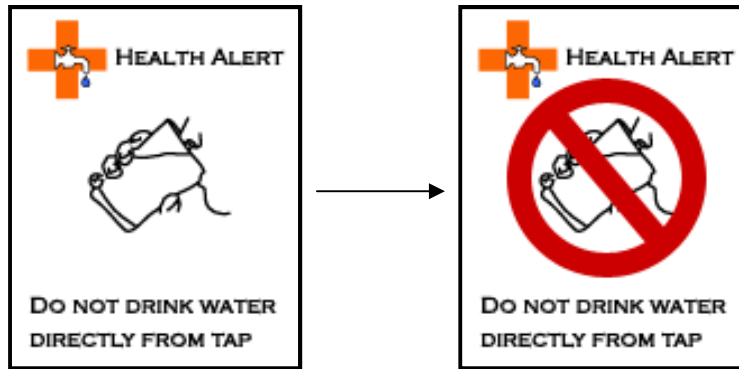


Figure 4-4. Animated Health Alert Picture Message

We developed an animated prototype of a boil water advisory as a template for the type of advice water service providers could issue following an alert. Use of this design would satisfy the advice consumers would normally receive from a health professional or from the media as revealed in the work flow diagrams above. The prototype symbol-based message forms a part of the complete water alert application. It could, however, serve as a stand-alone MMS text message too. So we decided to design and evaluate it with two users beforehand.

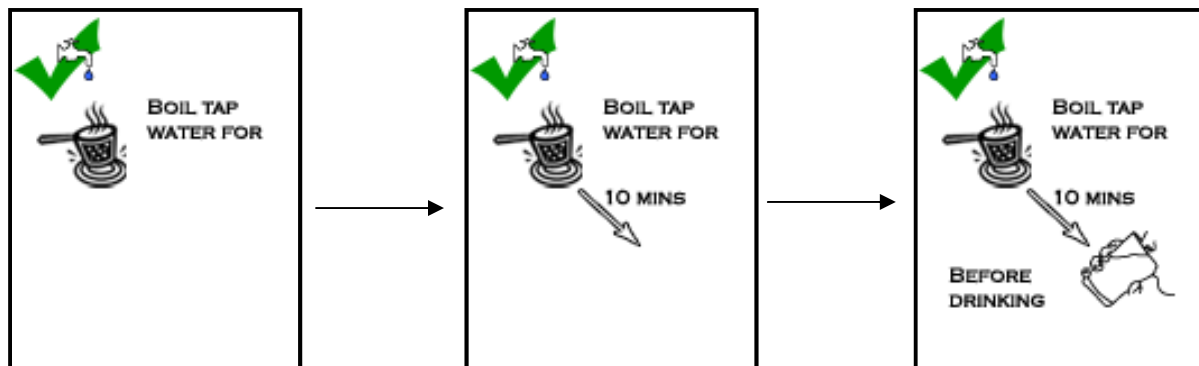


Figure 4-5. Animated Boil Water Advisory

FINDINGS AND EVALUATION

With each user, we first evaluated a text-free version of Figure 4-5 followed by the version with text shown there. Our evaluation revealed that in the text-free version, the participants were confused by the pot. One interpreted the drawing as “cook something for ten minutes then drink it.” This was only partially correct, as the intended meaning was “boil tap water for ten minutes before drinking”. In the version with text, however, the users interpreted the message correctly. One user suggested changing the pot to another graphic that made it clear water was being boiled. We changed the pot to a kettle as shown in Figure 4-6 below.



Figure 4-6. Prototype of the Boil Water Advisory

4.3 WATER QUALITY APPLICATION PROTOTYPE

We started off with a low-level user interface sketch to convey design ideas but not to evaluate it with end users (for the same reasons mentioned earlier).

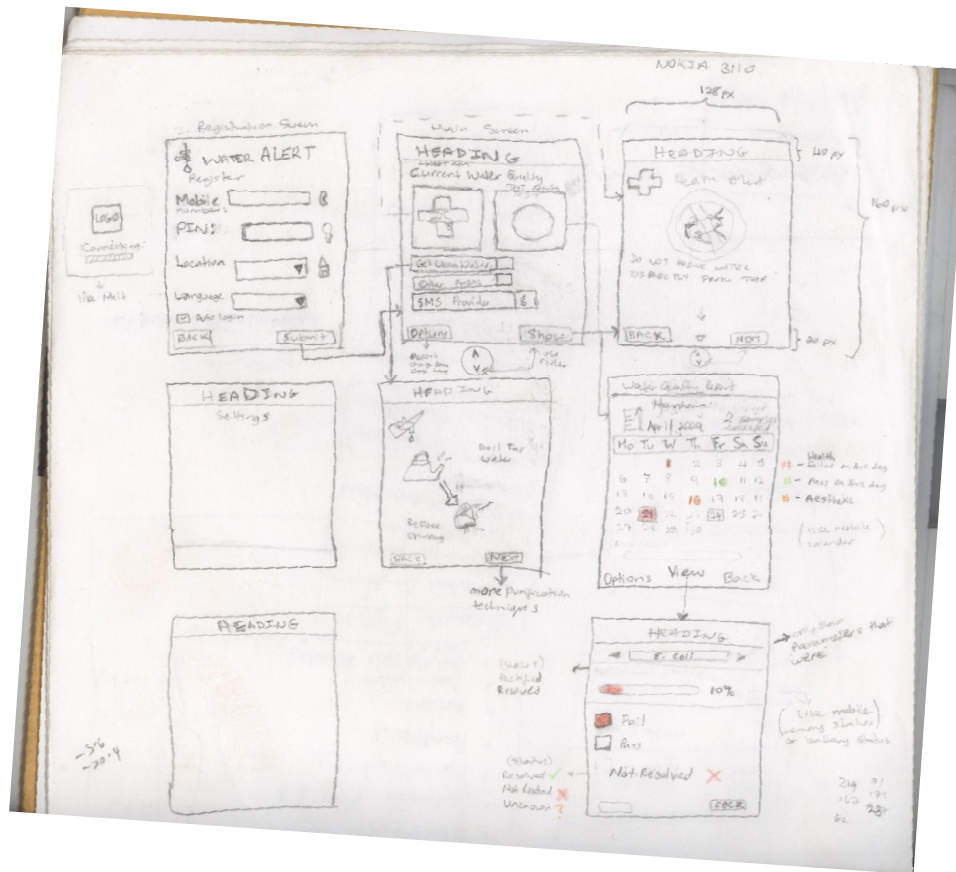


Figure 4-7. Low-Level User Interface Sketch

FLASH LITE PROTOTYPE

The Flash Lite prototype was developed on a Nokia 3110, which is a basic camera-ready handset supporting Flash 2.0, SMS and MMS text messaging. It is GPRS enabled, allowing the user to access the Mobile Internet. A full implementation of our proposed application would be portable to a wide variety of handsets with and without Flash capabilities since we would build it in on a more widespread platform. However, for the purpose of testing, we had to choose a Flash-ready phone, which could support our Flash Lite prototype. The handset had a relatively small screen, which would enable us to design an application still legible and usable on smaller screens.

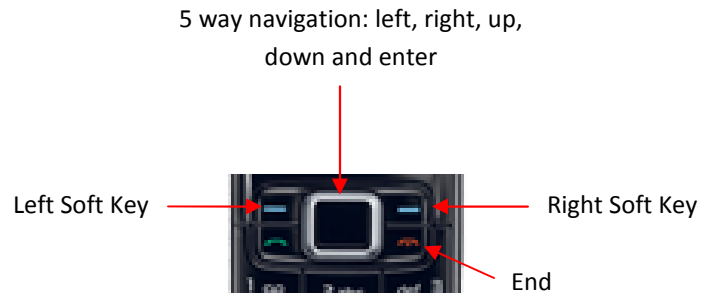


Figure 4-8. Nokia 3110 Handset

SUBSCRIBING TO THE WATER ALERT APPLICATION

The first time users start the application, they fill out a subscription form similar to a registering to MXit, Facebook mobile, or other phone applications. The page consists of text fields where they enter their cell phone number and select the location they are interested in receiving water quality information about and their language of choice. If it were previously filled out, the text fields would populate with information but would still allow users to change any of the fields if they desired. For instance, if users were interested in obtaining water quality information for another location outside of their home location, they would make that change here. The actual version would include an exclusive list of locations and language settings for the user to choose from. Our prototype, however, had text boxes rather than a drop-down list.

Once the user submits the form, the Main page shows the current water quality status of the user's area of interest. In this example, a health alert displays warning users not to drink the tap water directly. From this screen, the user can opt to get 'Advice' or to view the Water Quality Report.

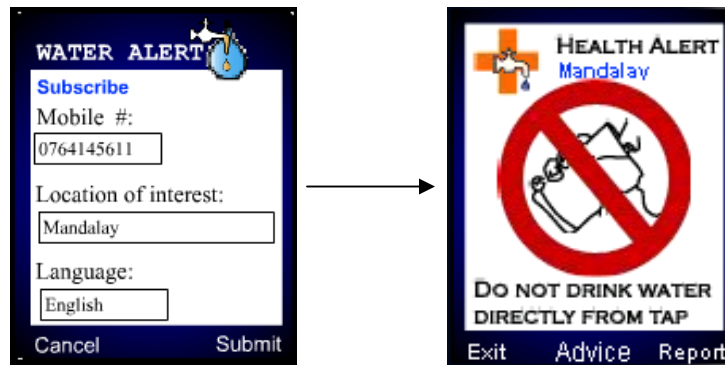


Figure 4-9: Water Alert! Subscription Screen and Water Quality Status Screen

VIEWING THE ADVICE SECTION

The user is taken to a series of animated picture messages when they select 'Advice'. The advice given here serves as a template for advice that could reside in this section of the application, since in the interview and on the questionnaires, users noted they were interested in learning more about, for example, the boil water advisory or other water purification techniques. The user can navigate between screens using the right and left soft keys and exit once the first or final advice screen is reached.

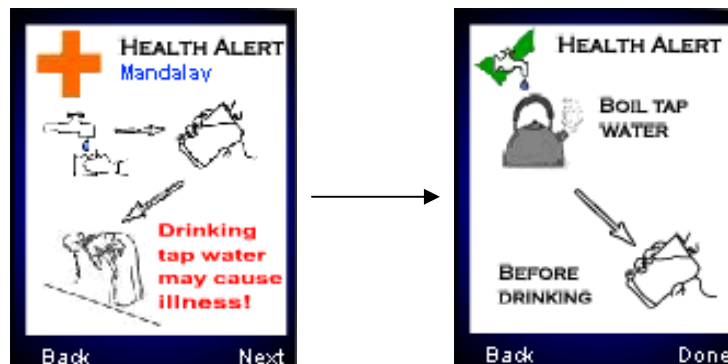


Figure 4-10. The Advice Screens Showing a Boil Water Advisory

ACCESSING THE WATER QUALITY REPORT

If the user chooses 'Report' from the Main screen, then they access the Water Quality Report. As mentioned earlier, we opted to use a calendar metaphor to translate a paper Water Quality Report into a cell-phone-based report. The main reason behind that is usability and understandability. Navigation on most calendar applications is similar with most users (as we learned during the interviews) having and understanding how to use the application. Furthermore, since Water Quality Reports are issued on a monthly basis, with tests performed on different days, this allowed for the calendar metaphor to present information, such as the result for testing for a specific day, to be easily visualized. Figure 4-12 shows the Water Quality Report in a calendar-like format. The day of the last test is automatically selected. Similar to a calendar application, other dates can be chosen. In our version, however, only the days on which a test was done are able to be selected. The color coding of the dates suggest (without having to access the report for a particular day) the overall water quality alert level for that testing. Moreover, when selected, the color of the text changes to white and the background highlight takes on the previous color of the date. We used a color scheme similar to that shown on an actual paper-based report, omitting blue, however, which stood for excellent, as we felt green was sufficient for labeling all compliant parameters. We explain the categories below:

- **Red:** one or more parameters tested resulted in health failures.
- **Amber (orange):** one or more parameters tested resulted in non-health failures, such as aesthetic or chemical failures.
- **Green:** all parameters tested were within compliance (passed).

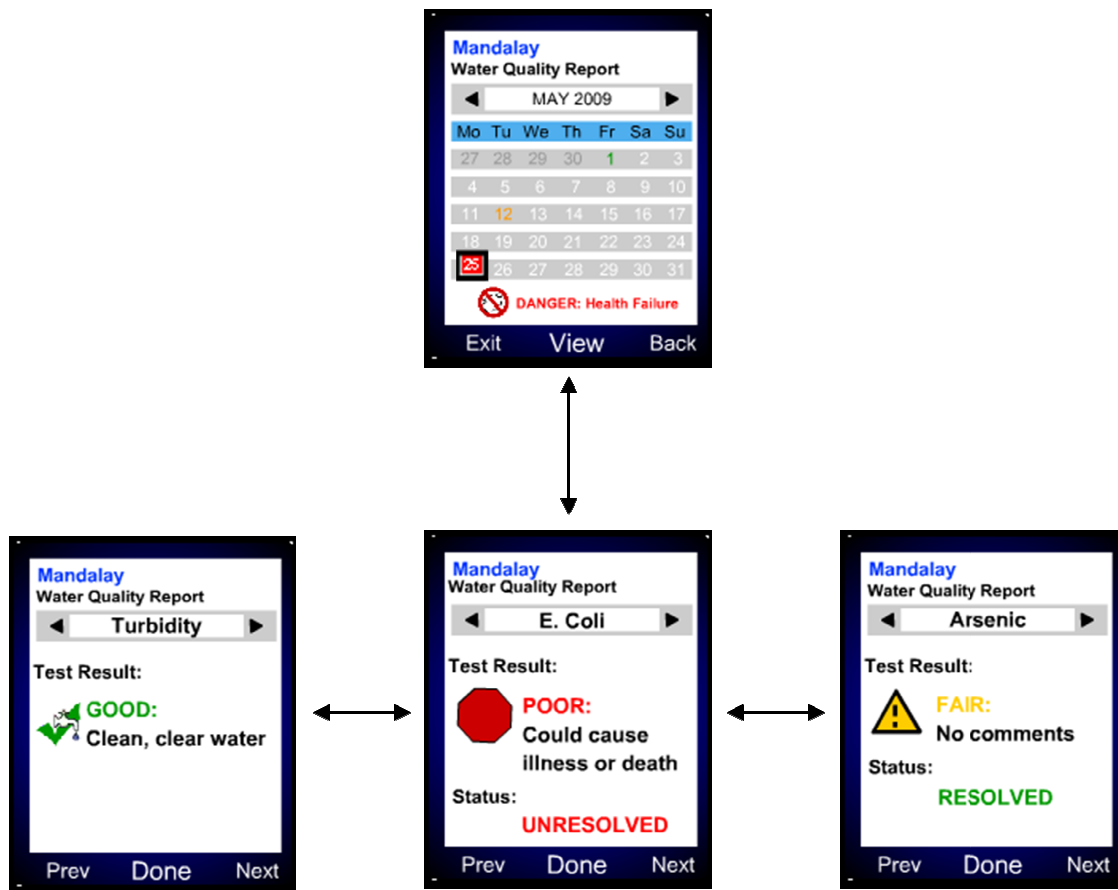


Figure 4-11. The Water Quality Test Results for a May 25, 2009 Testing

The user can access a more detailed report for a specific date by selecting 'View' with the Enter key. This brings up a symbol-based report of each parameter tested for indicating the result of the test. In the cases of a poor or fair test result, a status indicates whether the issue is 'resolved', 'unresolved', or 'no comments'. A brief explanation below each result subtly educates the user on the meaning of the parameters such as E. coli or Turbidity, which may be unfamiliar to many users.

5. USER TESTING AND EVALUATION

5.1 TESTING GOALS

We conducted both a formative and summative evaluation on the Water Alert Application. Due to time constraints, we conducted both simultaneously. Formative evaluation in the form of usability testing determines whether our application possessed the six key attributes of a usable product or service – “useful, efficient, effective, satisfying, learnable and accessible” – as outlined by Rubin and Chisnell (Rubin et al., 2008). Summative evaluation, in the form of a paper test, is issued to confirm the hypothesis that our Water Alert application *increases the consumer’s access to and interpretation of water quality test data*.

5.2 TEST PARTICIPANTS

RECRUITMENT/SCREENING

Since all consumers have a right to be informed about water quality, anyone 18 years or older, living or residing in South Africa, was a valid participant in this test. That being said, minimal screening was done with the use of a basic questionnaire ensured participants met the minimum age requirement. Due to time constraints, we only recruited users residing or present in the Cape Town area at the time we conducted the tests. A resident in the area with whom we built a relationship helped us to secure the participants. We found that people were more willing to participate if they were approached by another local or someone they already knew. Moreover, the resident was able to quickly explain in Afrikaans what our design was about to the participants who spoke that language (even though they also spoke English).

PARTICIPANTS’ PROFILE

A pilot test was conducted in Mandalay, a community in Cape Town. The participant was a male university student between 18 - 25 years of age. He reported owning a mobile phone and used applications on it such as MXit.

A total of four subjects (one male and three females) were chosen for the formal usability test and evaluation. Their ages fell in the range of 18 to 45 years old. Three users

either completed or had some secondary-level education, while one was completing a tertiary degree. Most held blue collar jobs, while one was a student. All spoke English fluently and were fluent in one or more languages, the most popular being Afrikaans. All but one user owned a mobile phone, and all those who owned a mobile phone reported having downloaded applications to it such as MXit and Opera. Two users lived in a formal area in a city, one in a small town and one in a rural area or village.

5.3 TEST DESIGN

We issued two tests to gauge the participants' understanding of a paper-based Water Quality Report (*see Appendix D*) and the phone-based Water Quality Report. The first test we issued consisted of two tasks, which involved the participant using a real paper-based Water Quality Report to find and respond to a set of questions. The second test consisted of a similar set of questions but required the participant to use the water alert phone application to complete the task and find the answers to the questions.

All formal testing was conducted in the Human Computer Interaction (HCI) lab at the University of Cape Town. Present at the test was the moderator who conducted the study and a timekeeper who tracked the time taken on tasks by the participants.

5.4 DATA COLLECTION AND ANALYSIS

A number of tools were used to collect data – an answer sheet, a voice recorder, a video camera and a stopwatch. The responses were recorded on the answer sheet by the moderator. A tape recorder was used to record the participant's comments throughout the entire session, while a handheld camera was used to record the actions of selected participants at certain points throughout the testing. The timekeeper used a stopwatch and a notebook to record the participant's time taken on tasks. In the pilot test the moderator was also the timekeeper. We noticed however, that with the moderator holding a stopwatch, the participant rushed through the tasks as he felt he had to complete it quickly. For the formal testing we introduced a timekeeper separate from the moderator and mentioned to the participants that he was responsible for ensuring that the session does not go overtime. The users seemed less tense as a result and worked at a slower pace than the participant in our pilot test.



Figure 5-1. Evaluation Session with Participant and Moderator

USABILITY METRICS

We kept track of the following qualitative and quantitative measures:

QUALITATIVE

- User comments

QUANTITATIVE

- Task completed?
- Time per task
- Test scores
- User ratings

FORMATIVE RESULTS

For each task carried out using both the paper report and our cell phone Water Alert System, we analyzed the qualitative data collected during the formative evaluation. Tasks were assigned in random order to prevent bias. We found on average the participants completed all

tasks using our system in 140.08 seconds, a 35% improvement in the time it took them to complete the same tasks using a real paper-based Water Quality Report.

In the following graphs, the blue shapes represent the time it took the participant to complete a task using the paper report. The green shapes represent the time taken to complete a task using our prototype Water Alert Phone application, and the green or blue diamonds represent instances when the participant reported that they just guessed an answer. This may have caused anomalies in the reported task completion time, since they would most likely have spent more time on the task had they not resorted to guessing.

In Task A, on average users took 84.7 seconds to complete the paper-based task whereas they took an average of 56 seconds to complete the same task using the prototype water-alert application. We omitted User 4's time taken on the paper-based task since she could not determine an answer and commented that she "cannot understand this". We also omitted the time completion of the phone-based task for user 3 who did not successfully complete the task.

User 3 is the only one who did not own or have access to a cell phone and reported having very little experience using one. Since this was the first task she attempted to complete on the phone, we felt her performance was affected by a high learning curve. For this phone-based task, she stuck to using two buttons to try to navigate the application, which resulted in her not reaching the appropriate screen necessary to complete the task. In the other cell-phone-based tasks, we observed that she explored other buttons and was able to complete them. User 1, our most experienced user, was the only one who did resort to guessing the answer for Task A. He clocked the second highest completion time when using the paper report but had the lowest completion time when using the phone application, an improvement in speed of two-thirds.

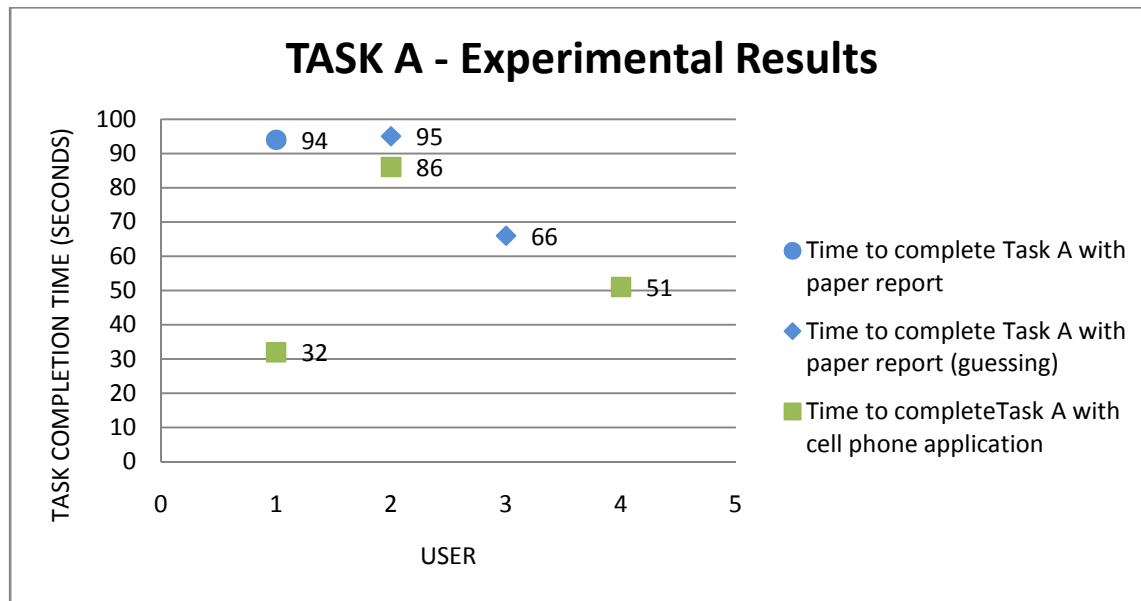


Figure 5-2. Experimental Results of Task A for Users Successfully Completing Task

**User 4 did not complete Task A with the paper report, so no time is reported.*

**User 3 did not complete Task A with the cell phone application, so no time is reported.*

For Task B, we see all users completed the task on the cell phone in less time than it took them to complete the task using a paper report. We also see that half the users reported guessing the answer to the question when using the paper report, whereas only user 3, our least experienced cell phone user, reported she just guessed an answer when completing the task on the cell phone. Users 1 and 4 did not resort to guessing in either instance, and we see an average improvement of 91.3% in the time it took for them to complete the task when they used the cell phone application.

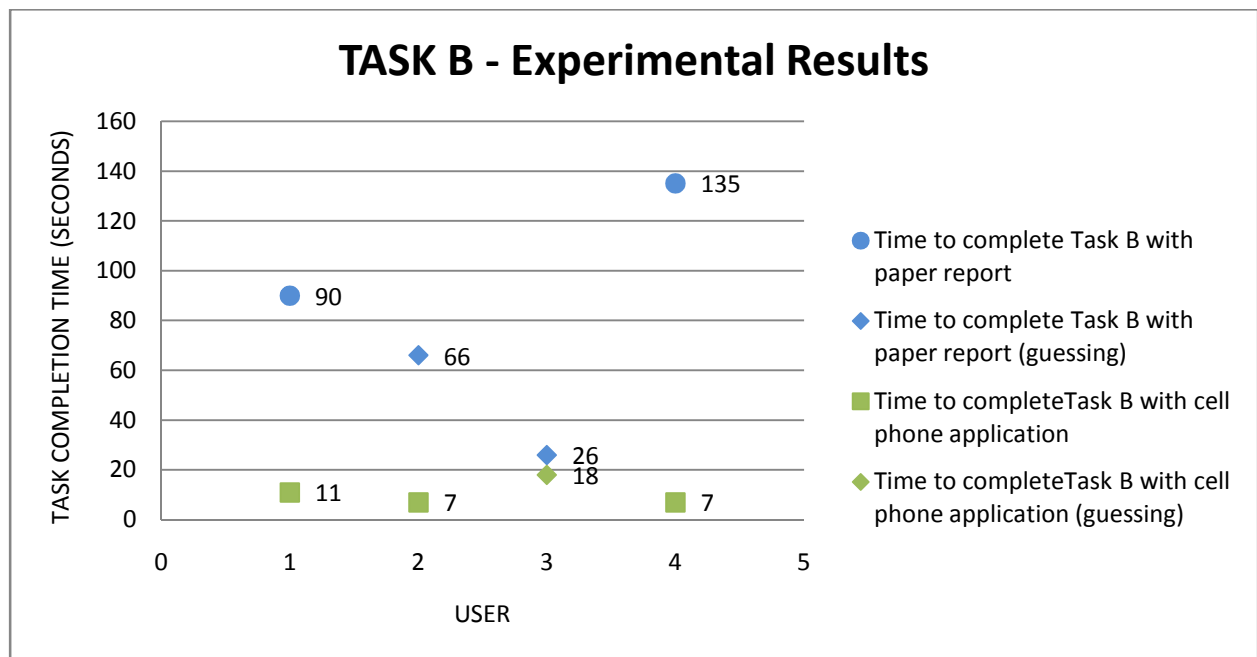


Figure 5-3. Experimental Results of Task B for Users Successfully Completing Task

Similar to Task B, all users in Task C completed the task on the cell phone in less time that it took for them to complete it using the paper report. In this case, no users reported guessing the answers for any of the questions posed. The time completion for the paper-based task ranged from 29 to 75 seconds, whereas a much lower range from 4 to 41 was reported when the task was performed using our prototype application.

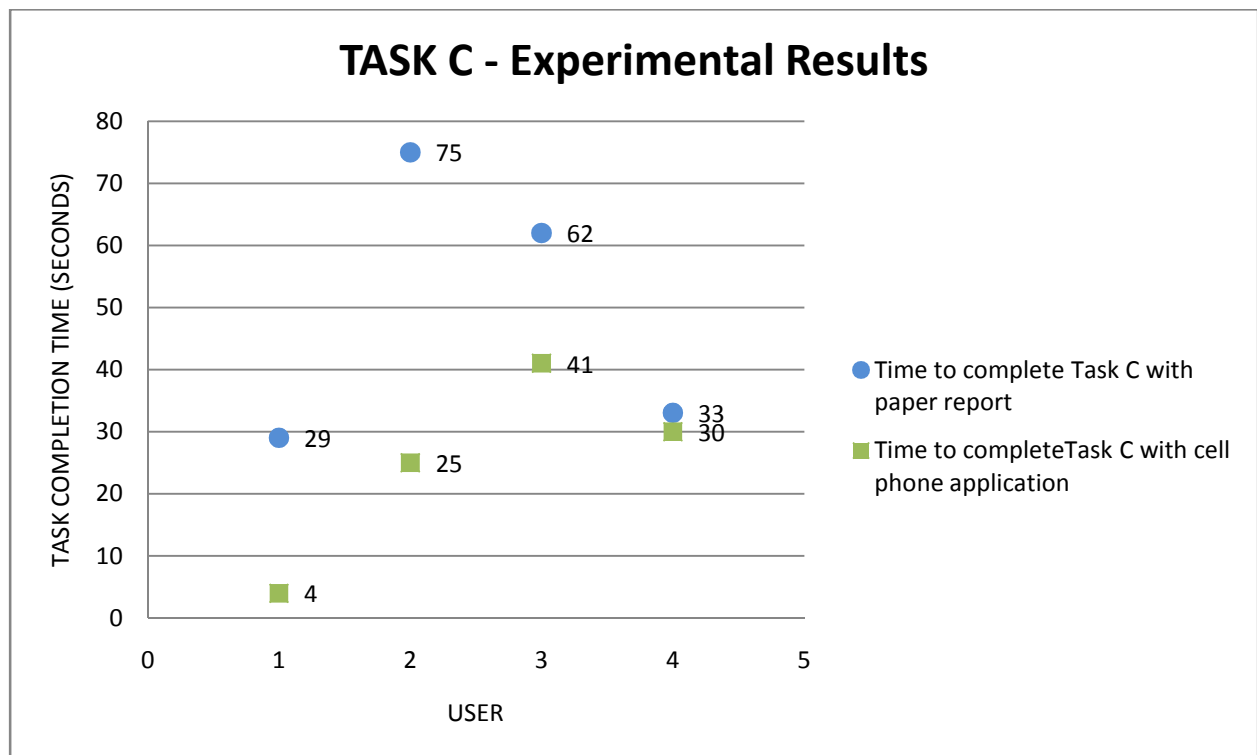


Figure 5-4. Experimental Results of Task C for Users Successfully Completing Task

SUMMATIVE RESULTS

We report the results of the test we issued to measure the users' levels of understanding of water quality information using first the old system – a complex paper-based Water Quality Report – followed by our new phone-based Water Quality Reporting prototype. Since we conducted a summative evaluation at the same time, we performed a usability test. This test determined whether while completing a task, a user went to the wrong screen and then proceeded to answer the question. We would allow them to continue so we could appropriately observe usability issues. However, at the end of the session, we would repeat the same question showing them the intended screen so they could accurately measure their interpretation of the intended screen. We did not inform them of our reason for doing that.

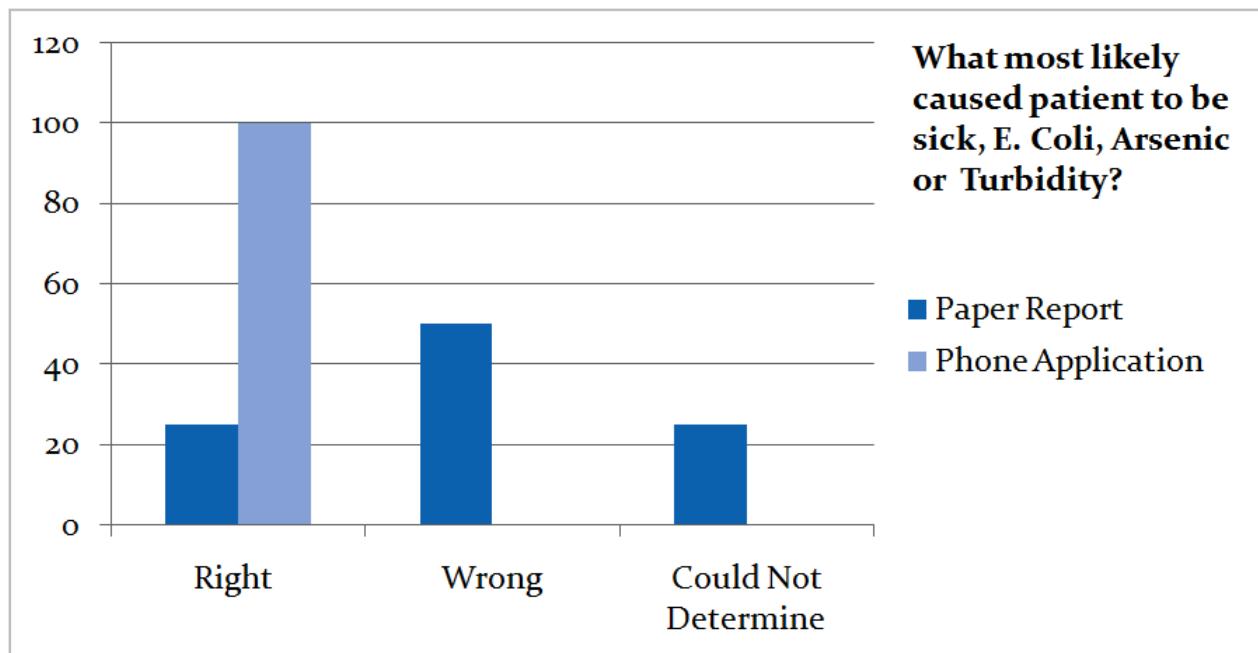


Figure 5-5. Results of the Participants' Responses in Task A

In Figure 5-5 above, we report the result of a task given. The user was given a scenario (see Appendix C) in which a nurse (the user) noticed an increase in the number of patients with diarrhea for a specific period and decided to check the Water Quality Report to figure out 'What most likely caused your patients to be sick, E. coli, Turbidity or Arsenic'. With the paper Water Quality Report, we see that after a lengthy period of deliberation only one user gave the correct response, whereas all other users were incorrect or said they just could not determine the answer because of the complexity of the paper-based report. The user who gave the correct answer when asked, "how did they determine this?" admitted they just guessed. For the phone-based application prototype, all users were able to correctly determine the most likely cause of their patient's illness. There was an increase in their confidence level when discussing how they determined their answers.

This next task, as outlined in Figure 5-6, required the user to determine the overall quality of water in a given area for the last twelve months. It is important to note that in this task, we used a paper prototype of our application since this feature was not yet built into the Flash prototype.

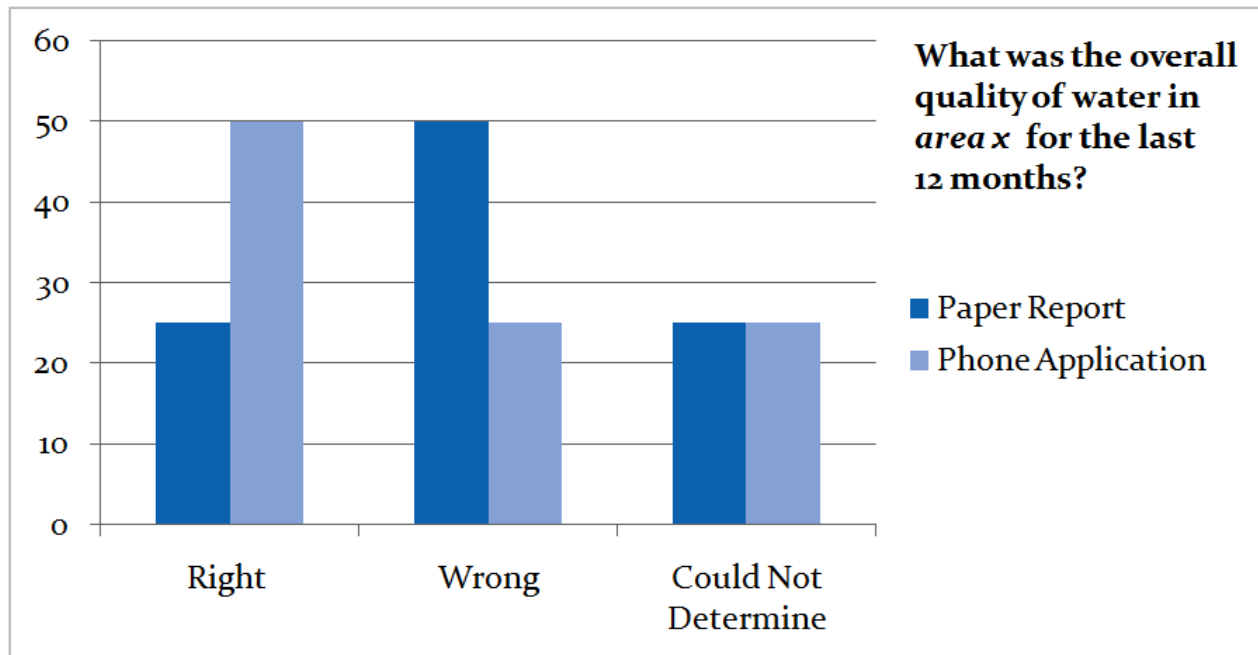


Figure 5-6. Results of the Participants' Responses in Task B

The outcome of this task, utilizing a real paper report, was the same as the task in Figure 5-5 using a paper report. The results when using our prototype, however, were more varied in this instance, which we concluded is due to the fact that we utilized a paper prototype that confused most of the participants. Even though they were told to imagine they were seeing this on their mobile phone, they made comments like 'the phone application had more details I prefer it,' suggesting they misunderstood that this was a low-level version of our prototype. This was consistent with the findings of Maunder et al. (2007) that low-level prototypes were not appropriate tools when evaluating design in developing world contexts.

We had the participants complete two additional tasks utilizing just the phone-based prototype and asked them two important questions: 'Is your tap water safe to drink?' and 'What is the advice given?' Both questions could not be determined by reading the paper Water Quality Report - a limitation of the current system. For both tasks, all participants quickly located the screen in our prototype that gave this answer and correctly answered the question, suggesting it was easy to obtain such critical information that our general user would be interested in, and it was easy to understand.

Figure 5-7 shows the percentage difference in the participants' understanding of water quality information when using a monthly paper report obtained from a local water service provider compared to when using *Water Alert!*, our phone-based Water Quality Reporting prototype application.

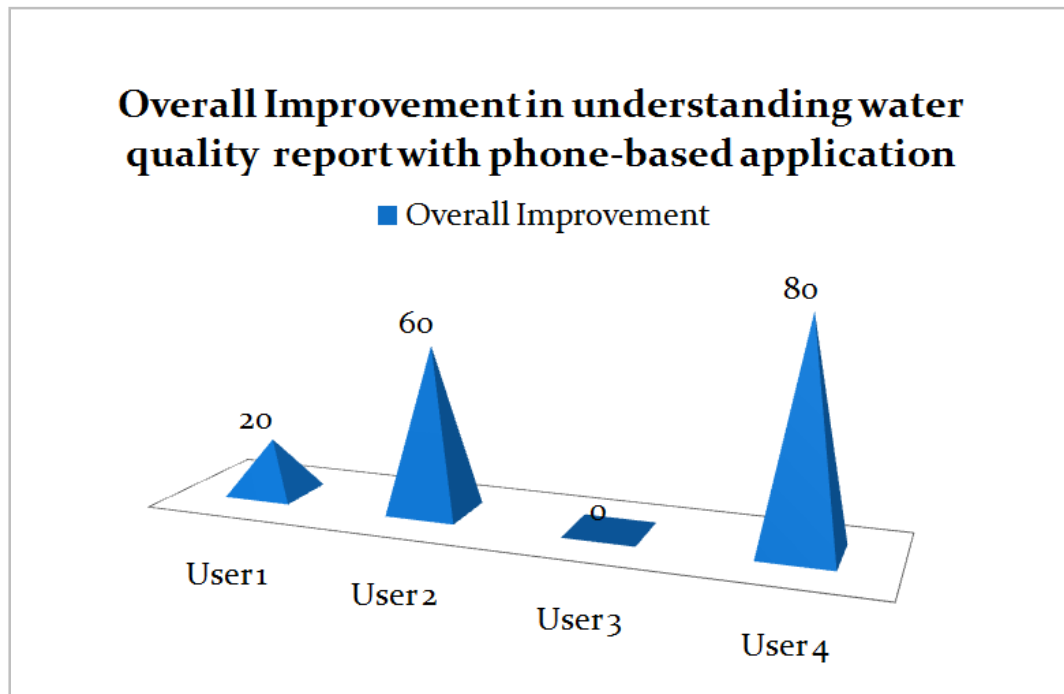


Figure 5-7: Percentage Improvement In Participants' Understanding of Water Quality Using Water Alert!

We see that on average, the participants experienced a forty percent increase in their level of understanding critical water quality information. We see three of four users experienced an increase ranging from twenty to as much as 80 percent, whereas User 3 experienced neither an increase nor a decline in his level of understanding of water quality information.

In addition to the test scores, we asked users to rate on a scale of 1 (very difficult) to 10 (very easy) how easy it was to understand the information shown in each task. Since most of the participants were new to the rating system, we explained how it worked through simple examples and a traffic light color-coded scale with ratings 1-3 in red, 4-7 in amber and 8-10 in

green. This self-analysis helped us to understand whether our participants felt a personal improvement in their understanding of water quality information having used our *Water Alert!* application.

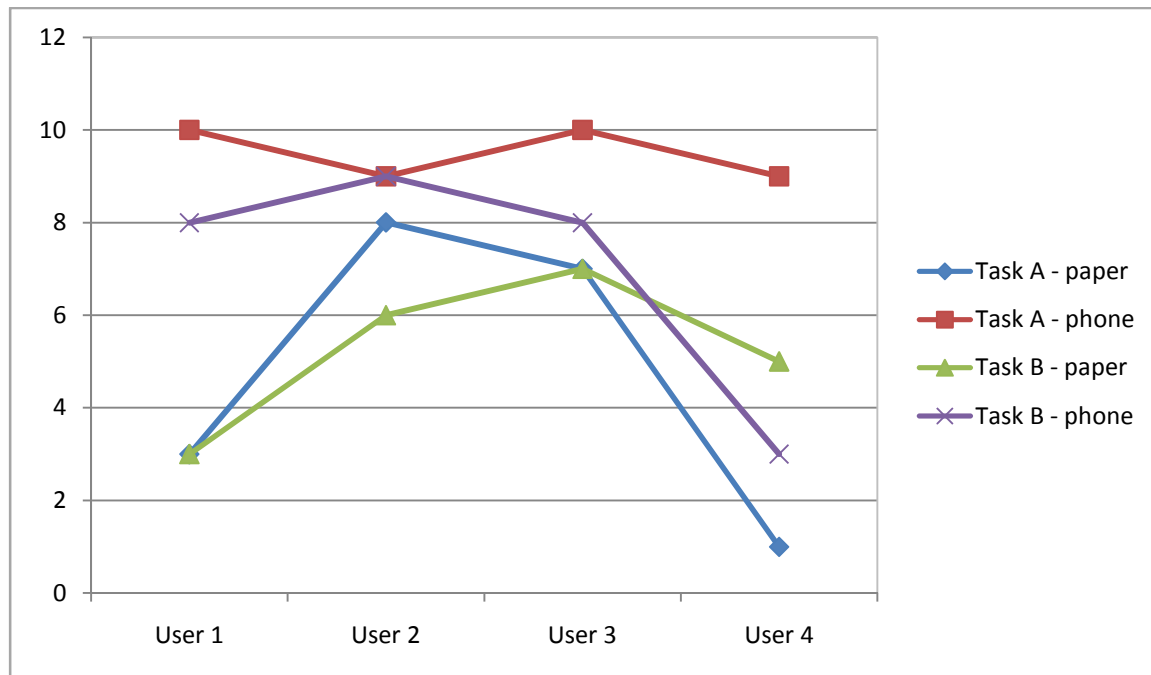


Figure 5-8. Participants' Rating of Ease of Understanding Water Quality Information Using the Different Media

We see that the self-reported ratings are consistent with the results on the test. Overall, participants experienced an improvement in their understanding of water quality information. For Task A and B using the paper-based report, participants reported an average rating of 4.75 and 5.25 consecutively for their ease of understanding the water quality information presented. They made comments such as:

“It is hard.”

“But how must I know what’s the meaning of this [E. coli] ...I just choose one, too hard to figure out.”

“I cannot understand this.”

For Task A and B using our *Water Alert!* Application, the participants reported an average rating of 9.5 and 7 consecutively, an average increased rating of 65 percent over the ratings reported for the paper-based tasks. They made comments such as:

“I like that it just boils down the numbers. I mean I wouldn’t care if E.Coli is at 75 or 73, I just want to know can I get it, what’s my risk?”

“It wasn’t so difficult.” “The pictures are easy to understand.”

Overall, they all reported liking our *Water Alert!* Application, making comments such as:

“I like the thing that you do here and I would like to have it on my phone to see what maybe if I’m sick today, my tummy is running, is the water okay to drink or what.”

“I like the instructions... does not just say your water is unsafe to drink, also says well here’s what you can do.”

“It was easy to understand because the report tells me everything what was wrong with water.”

CONCLUSION AND FUTURE STUDY

We conducted this research to address a critical missing link in the dissemination of water quality information by Water Service Providers - reporting water quality information to consumers. We outlined some areas of investigation which led us to the design of *Water Alert!*. This design solution is in line with our hypothesis – the use of appropriate Information and communication technologies (ICT) (such as a cell phone application and text messaging) coupled with culturally appropriate ways of presenting scientific information, increase the consumer's access to and interpretation of water quality test data...

We summarized the results of each area of our investigation as follows:

APPROPRIATENESS OF CELL PHONES

An investigation into current practices by researchers such as Loudon, Marsden and Maunder, who work in the field of ICT for Development, revealed the cell phone is a promising platform for the dissemination of information to the general public since it is highly accessible, widespread and is familiar to users in South Africa. Further, statistics released by the International Telecommunication Union showed a cell phone penetration level in South Africa that exceeds one hundred percent of the population (ITU, 2008).

From our own observations and the results of the questionnaires and interviews we conducted during the Contextual Inquiry Phase, we came to the conclusion that utilizing cellular technology was indeed our best option as far as an inexpensive, highly accessible means of disseminating information of this type. Following further investigation, we decided that designing a cell phone application was very versatile as we could design an information portal containing water quality information from all levels of users without compromising usability. In addition, our application could serve as a conduit (much like a nurse did) through which MMS or SMS text message water quality alerts can be sent to those who have not downloaded the application to their phone for whatever reason. Lastly, we saw that due to the popularity of applications such as MXit, and the cheap costs of Internet access, a phone application is a very

cost-efficient means of getting critical up-to-date information to South Africans who subscribe to such a service.

DESIGNING CULTURALLY-APPROPRIATE SYMBOL-BASED MESSAGES

The analysis of 87 photos taken of signs around Cape Town helped to guide our symbol-based messages. This led to a set of symbols and a color palette that is locally and potentially universally understood. It is from this analysis that we put together the messages shown in the application. After further modification of the application based on user feedback during each design iteration, we were able to develop a set of symbols our Cape Town participants understood.

SHIFTING A SCIENTIFIC PAPER-BASED WATER QUALITY REPORT TO AN ACCESSIBLE CELL PHONE-BASED REPORT

Our use of a cell phone calendar metaphor to design a phone-based-report proved to be successful, as even our most novice user who did not own a cell phone was able to navigate through our application with few errors after minimal exposure to the application. Moreover, our report is simple enough that the general consumer can access it. While they are also educated about water quality test results, enough information needs to be provided so that advanced users (such as nurses) may obtain more than the basic information about water quality test results.

FUTURE STUDY

Due to a ten-week time constraint, our project was limited to the Cape Town area. To test our hypothesis at a level of statistical significance, a larger study could be conducted to reach a wider cross-section of South Africans. Additionally, an analysis and evaluation of symbols in rural areas (which have fewer roads) would help with designing area-specific messages for a more rural setting.

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APPENDIX A: QUESTIONNAIRE

QUESTIONNAIRE

The purpose of this survey is to improve the communication of water quality information between Water Service Providers and the people of South Africa. The information provided will be kept strictly confidential.

BACKGROUND INFORMATION

1. Gender: ☐ male ☐ female

2. Age group: ☐ 18 – 25
 ☐ 26 – 45
 ☐ 46 – 65
 ☐ > 65

3. Is the area where you live: *(select one)*
 ☐ a formal area in a city
 ☐ an informal settlement in a city
 ☐ a large town
 ☐ a small town
 ☐ a rural area or village

4. Education level: *(select one)*
 ☐ No formal schooling
 ☐ Some primary schooling
 ☐ Completed primary school (Standard 5/Grade 7 or above)
 ☐ Some secondary schooling
 ☐ Completed secondary school (Standard 10/Grade 12/Matric)
 ☐ Tertiary qualification (Degree or Diploma)
 ☐ Postgraduate qualification (Masters or PhD)

5. Occupation: _____

6. Language(s) spoken:

- | | | |
|-----------------------------------------|-----------------------------------------|------------------------------------|
| <input type="checkbox"/> English | <input type="checkbox"/> Xhosa | <input type="checkbox"/> Afrikaans |
| <input type="checkbox"/> Tswana | <input type="checkbox"/> Tsonga | <input type="checkbox"/> Venda |
| <input type="checkbox"/> Ndebele | <input type="checkbox"/> Swati | <input type="checkbox"/> Zulu |
| <input type="checkbox"/> Northern Sotho | <input type="checkbox"/> Southern Sotho | |

DRINKING WATER QUALITY INFORMATION

7. Where do you mainly get your water for daily usage (e.g., cooking, drinking)?

8. *Rate the overall quality of drinking water in your area:*

| | Excellent | Good | Fair | Poor | Don't know |
|------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Appearance: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Taste: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Healthiness: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Overall quality: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

9. How concerned are you about the quality of drinking water in your area?

- ☐ very concerned ☐ somewhat concerned ☐ not concerned

10. How important is it for you to be informed about the quality of drinking water in your area?

- ☐ very important ☐ somewhat important ☐ not important

11. How frequently do you get information about the quality of drinking water in your area?

- ☐ daily ☐ at least once a week ☐ at least once a month
☐ at least once a year ☐ never

12. How are you informed about drinking water quality in your area? (*check all that apply*)

- ☐ Posters ☐ Television/radio ☐ Newspapers ☐ SMS/MMS
☐ Community leader/member ☐ Health professional (e.g., nurses) ☐ Not informed
☐ Other(s) (*please specify*): _____

13. Rate your level of knowledge about the following:

| | High | Medium | Low | None |
|------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Water quality testing: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Interpreting water quality test results: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Types of contaminants found in water (e.g., E. coli & fecal coliforms) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Drinking water purification techniques: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

14. Check the items you would like to learn more about:

- ☐ Drinking water quality in your current area
☐ Drinking water quality in other areas
☐ Drinking water quality over a period of time (e.g., month, year)
☐ Ways to purify contaminated drinking water
☐ Other (*please specify*): _____

INFORMATION ACCESSIBILITY

15. Do you own or have access to a mobile phone? *(if no, skip to 16)*

☐ Own ☐ Have access ☐ No

b. Do you download applications on your mobile phone (e.g., MXit, Opera Mini)?

☐ Yes ☐ No

c. What application(s) do you have access to? *(check all that apply)*

☐ SMS (Text Message) ☐ MMS (Multimedia Message) ☐ MXit

☐ Opera/other browser ☐ E-mail ☐ Instant Messenger (e.g., Yahoo/MSN messenger)

☐ Other(s) *(please specify)*: _____

d. Rank the applications you use on your mobile phone beginning with: 1 (for most used), 2 (second most used), and so on. Write zero for the applications you do not use.

___ SMS (Text Message) ___ MMS (Multimedia Message) ___ MXit

___ Opera/other browser ___ E-mail ___ Instant Messenger (e.g., Yahoo/MSN)

___ Other: _____ ___ Other: _____

16. Do you have access to the internet? ☐ Yes ☐ No *(if no, skip to 17)*

b. How do you usually access the internet? *(select one)*

☐ mainly on mobile phone

☐ mainly on desktop/laptop computer

☐ mainly on mobile phone, occasionally on desktop/laptop computer

☐ mainly on desktop/laptop computer, occasionally on mobile phone

☐ about the same on both mobile phone and desktop/laptop computer

☐ Other *(please specify)*: _____

c. What do you mainly use it to do? (*check all that apply*)

☐ Search for information

☐ E-mail

☐ Online shopping

☐ Browse websites

☐ Instant Messenger (e.g., Yahoo/MSN messenger)

☐ Blog/Personal pages (e.g., Facebook, MySpace)

☐ Work/School purposes

☐ Other(s) (*please specify*): _____

d. How often do you access the internet? (*select one*)

☐ daily

☐ at least once a week

☐ at least once a month

☐ at least once a year

☐ never

17. What are your top three sources of information? (*select three*)

☐ Information services on mobile phone (MMS/SMS based)

☐ Mobile Internet

☐ Mobile phone applications

☐ Internet (on a computer)

☐ Posters

☐ Television/Radio

☐ Newspapers

☐ Community leader/member

☐ Local professionals (e.g., nurses)

☐ Other(s) (*please specify*): _____

CONSUMER PREFERENCES

18. How would you prefer to receive information about water quality in your area? (*check all that apply*)

☐ Information services on mobile phone (via SMS/MMS texts)

☐ Mobile Internet (e.g., Opera)

☐ Internet (on desktop/laptop)

☐ MXit

☐ Mobile phone application

☐ Posters

☐ Television/Radio

☐ Newspapers

☐ Community leader/member

☐ Local professionals (e.g., nurses)

☐ E-mail

☐ Other(s) (*please specify*): _____

19. Would you send a text message requesting water quality information if you had to pay the regular cost of sending a text message? ☐ yes ☐ no

20. Would you send a text message requesting water quality information if there were no associated costs with sending the text? ☐ yes ☐ no

21. Would you missed-call a number (call and hang up to avoid being charged, but to initiate a information request) or send a 'please call me' text message that would send you water quality information, with no associated costs? ☐ yes ☐ no

22. Would you download a phone application that would give you updates on water quality information when accessed? ☐ yes ☐ no

23. How often would you like to receive information about drinking-water quality in your area? (*check one*)

☐ only when critical ☐ daily & when critical ☐ once a week & when critical

☐ once a month & when critical ☐ once a year & when critical ☐ never

24. How important is it for you to have a means of communicating to your water service provider issues or questions relating to water quality in your area?

☐ very important ☐ somewhat important ☐ not important

25. Other comments or suggestions for a Water Quality Reporting/alerting service?

APPENDIX B: WORK MODELS

FLOW MODELS

Figure B-1. Consumer U1 of Flow Model

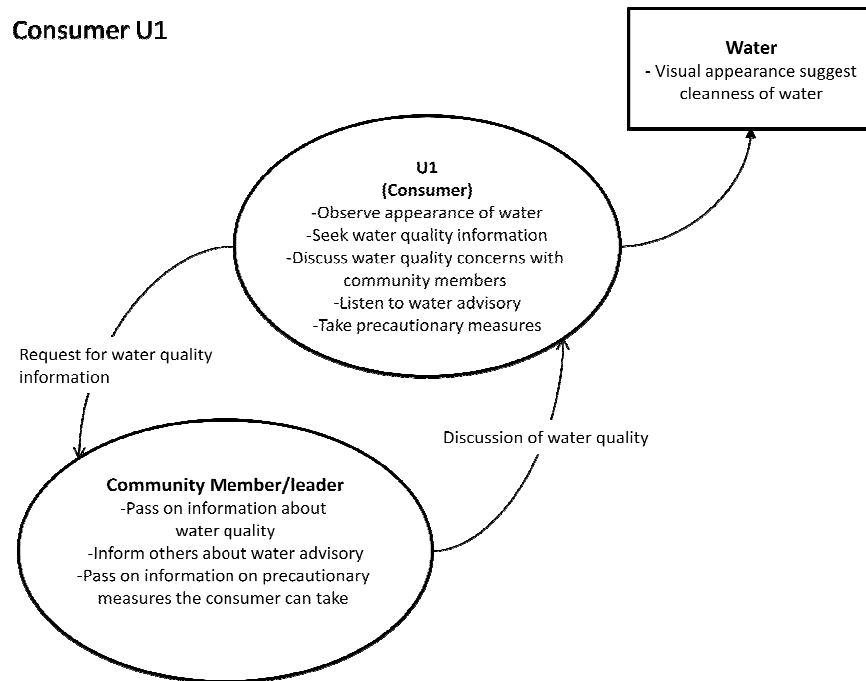


Figure B-2. Consumer U2 of Flow Model

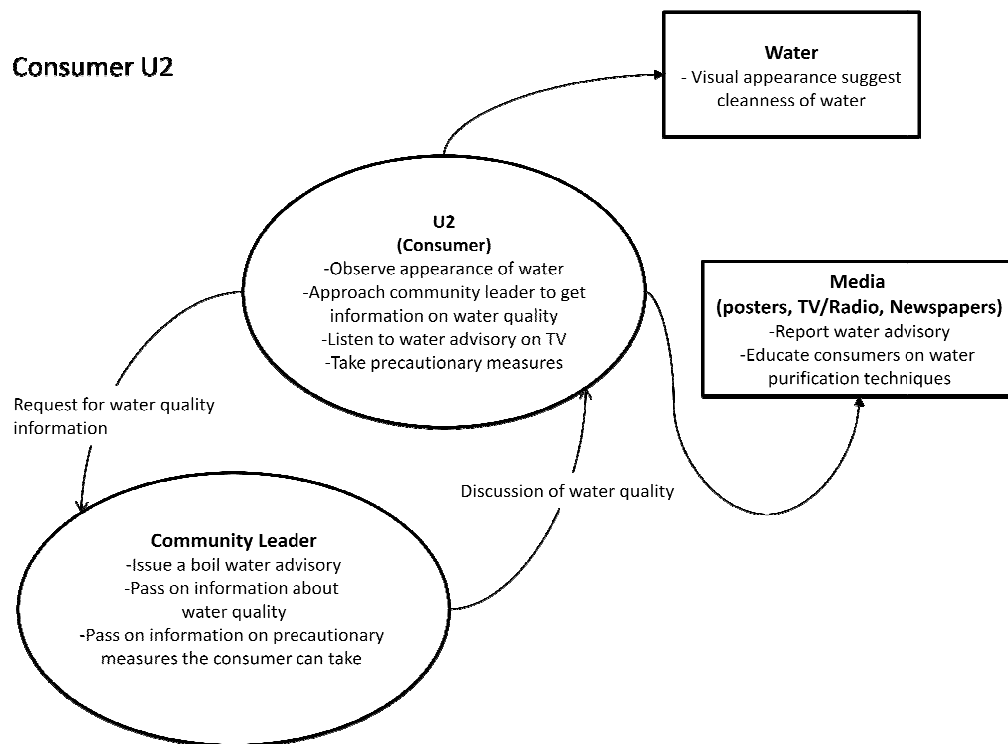
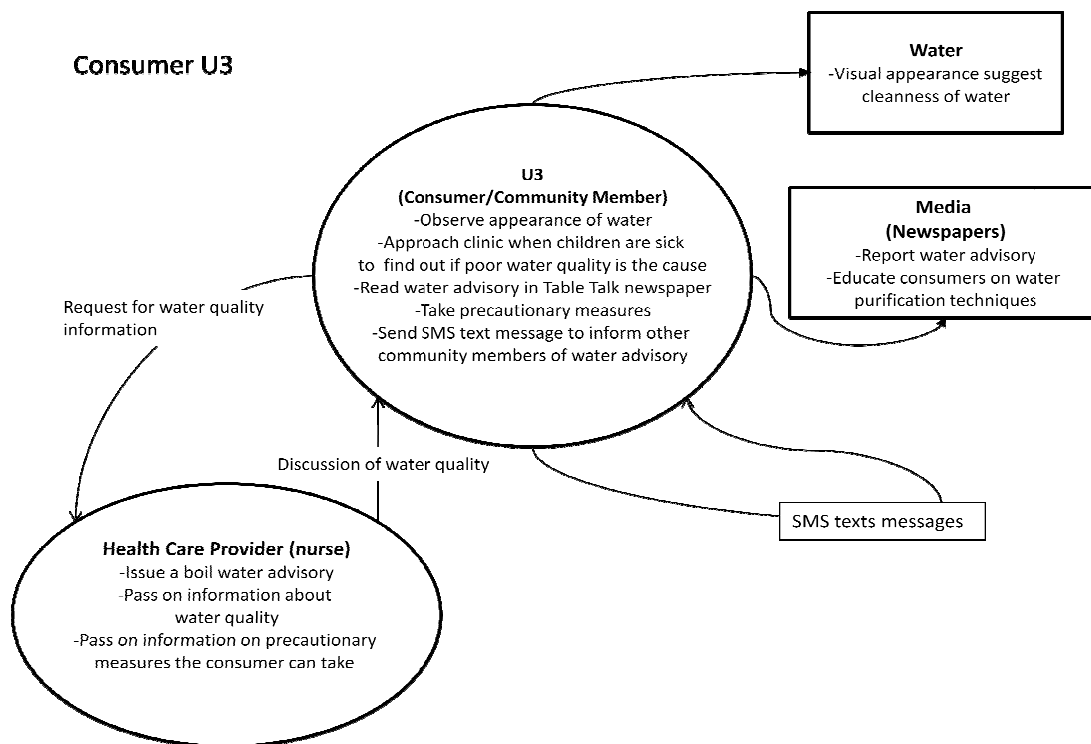


Figure B-3. Consumer U3 of Flow Model



SEQUENCE MODELS

Figure B-4. Consumer U1 of Sequence Model

Consumer U1

Intent: To know if water is safe to drink

Trigger: Cloudy , poor tasting water
coming from stand pipe after a period of
disrupted water supply.

*Waits passively to
receive water quality information*

Discusses water quality concerns
with community members

Intent: To be informed about
precautionary measures
to take

Listens to advice from community members
to refrain from drinking tap water for a few days

Intent: To protect health

Follows advisory until informed that water
is safe to drink

Figure B-5. Consumer U2 of Sequence Model

Consumer U2

Intent: To know cause of poor appearance of tap water

Trigger: Whitish water coming from the tap

Approach community leader to find out the reason

Receive information about the quality of the tap water

Receive a boil water advisory from community leader

Intent: To protect health

Follows advisory until informed that water is safe to drink

Figure B-6. Consumer U3 of Sequence Model

Consumer U3

Intent: To know cause of children's illness

Trigger: Children get sick (gastroenteritis, diarrhea)

Go to the clinic to find out the reason for children's illness from a health care provider

Receive information that poor water quality is the cause of children's illness

Intent: To know how to help children recover

Request advice on what to do

Listens to advice from nurse to refrain from drinking tap water for a few days

Intent: To prevent children's illness from becoming more severe

Follows advisory until informed that water is safe to drink

APPENDIX C: WATER QUALITY COMPREHENSIVE TEST

PAPER-BASED TASKS

TASK A

You are a nurse and you suspect that most of your patients from Calvinia got sick after drinking tap water. So you get the latest paper report from the water service provider in Calvinia and you check to see what might have caused their illness. You look at the results for E. Coli, Arsenic and Turbidity.

1. Based on the results shown what most likely caused your patients to be sick after drinking tap water?
☐ E. Coli ☐ Turbidity ☐ Arsenic ☐ Cannot determine
2. How did you determine this?
3. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to understand the information shown?

TASK B

You want to know the overall quality of water in your area (Calvinia) for the last 12 months, so you check the latest paper report from your water quality provider to find out.

1. What was the overall quality of water in Mandalay for the last 12 months (May 2008 – April 2009)?
☐ Excellent ☐ Good ☐ Fair ☐ Poor ☐ Cannot determine
2. How did you determine this?
3. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to understand the information shown?

TASK C

View the Water Quality Report on your phone and rate the following parameters based on what is shown.

| Excellent | Good | Fair | Poor | Cannot determine |
|-----------|------|------|------|---------------------|
| E. Coli | | | | |
| Arsenic | | | | |
| Turbidity | | | | |

Table B-1. Water Quality Report Parameters

PHONE-BASED TASKS

TASK A

You are a nurse and you suspect that most of your patients from Mandalay got sick after drinking tap water. You access the Water Quality Report on your mobile phone for May 12 to see what might have caused their illness. You see results for three parameters tested: E. Coli, Arsenic and Turbidity.

1. Based on the results shown, what most likely caused your patients to be sick after drinking tap water?

☐ E. Coli ☐ Turbidity ☐ Arsenic

2. How did you determine this?

3. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to find this information?

4. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to understand the information shown?

TASK B

You want to know the overall quality of water in your area (Mandalay) for the last 12 months, so you access the water quality application to find out.

1. What was the overall quality of water in Mandalay for the last 12 months (May 2008 – April 2009)?

☐ Excellent ☐ Good ☐ Fair ☐ Poor ☐ Cannot determine

2. How did you determine this?

3. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to understand the information shown?

TASK C

View the Water Quality Report on your phone and rate the following parameters based on what is shown.

| | Excellent | Good | Fair | Poor | Cannot determine |
|-----------|-----------|------|------|------|---------------------|
| E. Coli | | | | | |
| Arsenic | | | | | |
| Turbidity | | | | | |

Table B-2. Water Quality Report Parameters

TASK D

Your community was without water for a few days, but it returned today. You are concerned if the water is safe to drink so you check the water alert application on your phone.

1. Is the water safe to drink?
☐ Yes ☐ No ☐ Cannot determine
2. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to find this information?
3. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to understand the information shown?

TASK E

You found out that water in your area is not safe to drink. You want to get advice on what to do in this situation so you check the water alert application on your phone.

1. What is the advice? How did you determine this?
2. What did it say might happen if you drink the water? How did you determine this?
3. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to find this information?
4. On a scale of 1 (very difficult) to 10 (very easy) how easy was it to understand the information shown?

APPENDIX D: PAPER-BASED WATER QUALITY REPORT

Below are sample pages from a real water quality report for the Hantam municipality in South Africa that were modified and used during the evaluation phase.

Figure D-1. Sample Page from Water Quality Report

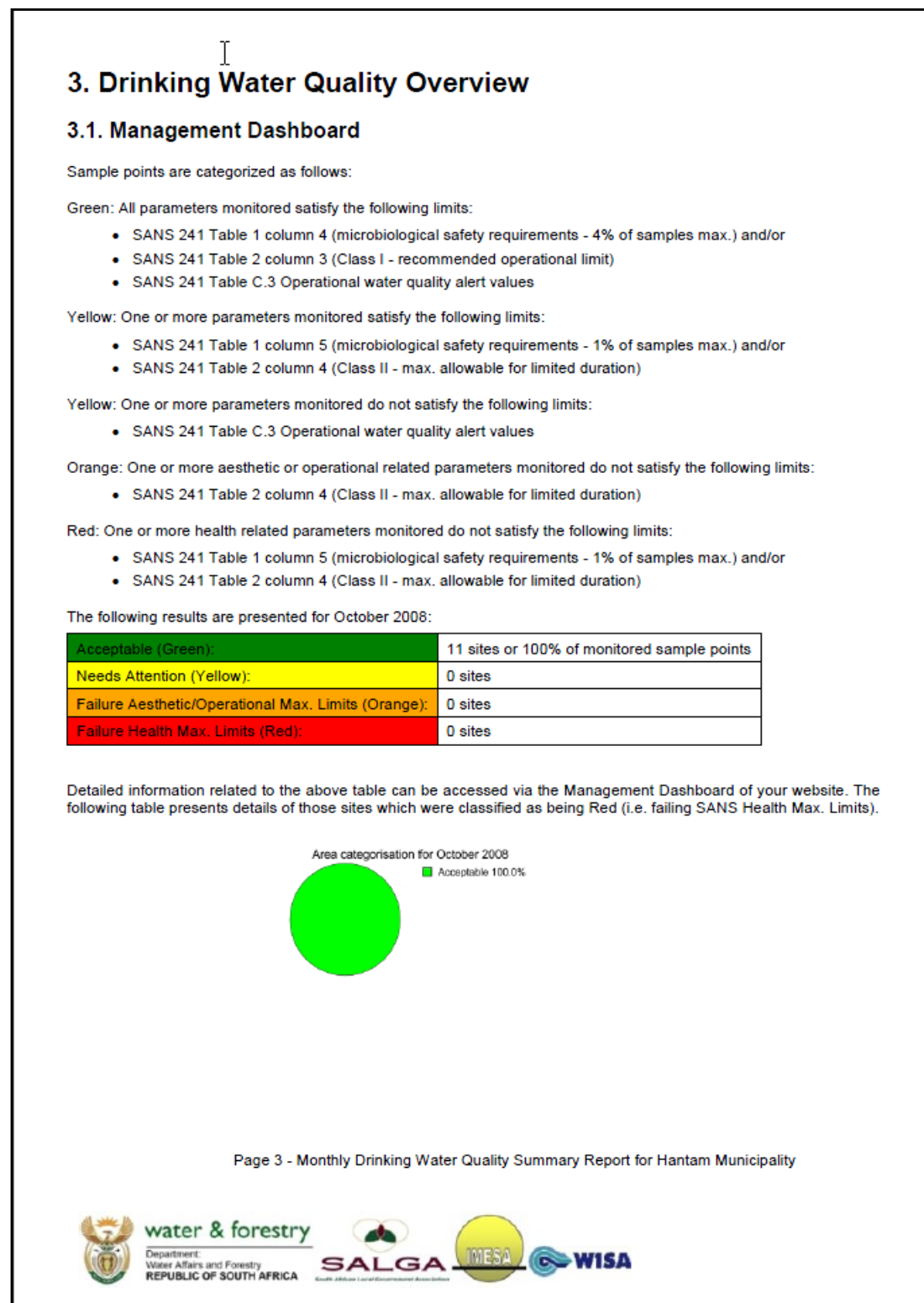


Figure D-2. Sample Page from Water Quality Report

2. Overview of Percentage Compliance vs. SANS 241 for the Last 12 Months

Microbiological Safety

| Area | Faecal Coliforms (health) | | E.coli (health) | |
|-------------------------------|---------------------------|--------------|-----------------|--------------|
| | SampleCount | Compliance % | SampleCount | Compliance % |
| South Africa | 14248 | 98 | 50287 | 98 |
| Northern Cape | 374 | 98 | 3592 | 94 |
| Namakwa District Municipality | 43 | 91 | 688 | 91 |
| Hantam Municipality | 0 | - | 133 | 98 |
| Brandvlei | 0 | - | 23 | 98 |
| Calvinia | 0 | - | 47 | 98 |
| Loeriesfontein | 0 | - | 27 | 98 |
| Middelpos | 0 | - | 11 | 100 |
| Nieuwoudtville | 0 | - | 25 | 100 |

Notes:

- The percentage compliance displayed is the percentage of all samples collected in the area falling within SANS: Microbiological Safety: Column 5.
- Based on samples taken during the last 12 months.

SANS 241 Table C.2: Compliance frequency targets in respect of microbiological and chemical requirements that have health implications

| Quality of Water System | Microbiological requirement | Chemical requirement | |
|-------------------------|-----------------------------|----------------------|----------|
| | Column 5 of Table 1 | Class I | Class II |
| Excellent | >= 99% | >= 95% | >= 97% |
| Good | >= 98% | >= 90% | >= 95% |
| Fair | >= 97% | >= 85% | >= 90% |
| Poor | <97% | <85% | <90% |



Figure D-3A. Sample Page from Water Quality Report

Microbiological Operational

| Area | Total Coliforms (operational) | |
|-------------------------------|-------------------------------|--------------|
| | SampleCount | Compliance % |
| South Africa | 50506 | 89 |
| Northern Cape | 3636 | 75 |
| Namakwa District Municipality | 650 | 72 |
| Hantam Municipality | 133 | 89 |
| Brandvlei | 23 | 74 |
| Calvinia | 47 | 94 |
| Loeriesfontein | 27 | 85 |
| Middelpos | 11 | 91 |
| Nieuwoudtville | 25 | 96 |

Notes:

- The percentage compliance displayed is the percentage of all samples collected in the area falling within SANS: Operational Limits: Acceptable Level.
- Based on samples taken during the last 12 months.

Figure D-3B. Sample Page from Water Quality Report

Appendix C

This section highlights the following:

1. Percentage compliance versus SANS 241 for the report period (i.e. 1 month) for the following parameters:

- Microbiological
- Physical
- Chemical

2. Overview of percentage compliance versus SANS 241 for the last 12 months for the following parameters:

- Microbiological
- Physical
- Chemical

1. Percentage Compliance vs. SANS 241 for the Report Period

| Parameters: | Unit Of Measure | Number of Samples | SANS 241 | | | |
|-------------------------------|------------------|-------------------|----------------------------------------|----------------------------------------|--------------------------------------------|----------------------------------------|
| | | | SANS: Microbiological Safety: Column 3 | SANS: Microbiological Safety: Column 4 | SANS: Operational Limits: Acceptable Level | SANS: Microbiological Safety: Column 5 |
| Microbiological | | | | | | |
| Total Coliforms (operational) | count per 100 mL | 13 | - | - | 100.0 | - |
| Faecal Coliforms (health) | count per 100 mL | 0 | - | - | - | - |
| E.coli (health) | count per 100 mL | 13 | 100.0 | 100.0 | - | 100.0 |

| Parameters: | Unit Of Measure | Number of Samples | SANS 241 | |
|-------------------------------------|-----------------|-------------------|-------------------------------------------------------|--------------------------------------------------------|
| | | | SANS: Physical, Organoleptic, Chemical: Class I | SANS: Physical, Organoleptic, Chemical: Class II |
| Physical | | | | |
| Colour (aesthetic) | mg/L Pt | 0 | - | - |
| Electrical Conductivity (aesthetic) | mS/m | 0 | - | - |
| Odour (aesthetic) | TON | 0 | - | - |
| pH (aesthetic/operational) | pH units | 0 | - | - |
| Taste (aesthetic) | FTN | 0 | - | - |
| Total Dissolved Solids (aesthetic) | mg/L | 0 | - | - |

Page 12 - Monthly Drinking Water Quality Summary Report for Hantam Municipality



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Water Affairs and Forestry
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SALGA
South African Local Government Association



Figure D-3C. Sample Page from Water Quality Report


| Parameters: | Unit Of Measure | Number of Samples | SANS 241 | |
|---------------------------------------------------|-----------------|-------------------|-------------------------------------------------|--------------------------------------------------|
| | | | SANS: Physical, Organoleptic, Chemical: Class I | SANS: Physical, Organoleptic, Chemical: Class II |
| Physical | | | | |
| Turbidity (aesthetic/operational/indirect health) | NTU | 0 | - | - |

| Parameters: | Unit Of Measure | Number of Samples | SANS 241 | |
|---------------------------------------------|-----------------|-------------------|-------------------------------------------------|--------------------------------------------------|
| | | | SANS: Physical, Organoleptic, Chemical: Class I | SANS: Physical, Organoleptic, Chemical: Class II |
| Chemical | | | | |
| Aluminium (health) | mg/L as Al | 0 | - | - |
| Ammonia (operational) | mg/L as N | 0 | - | - |
| Antimony (health) | ug/L as Sb | 0 | - | - |
| Arsenic (health) | mg/L as As | 0 | - | - |
| Cadmium (health) | mg/L as Cd | 0 | - | - |
| Calcium (aesthetic/operational) | mg/L as Ca | 0 | - | - |
| Chloride (aesthetic) | mg/L as Cl- | 0 | - | - |
| Chromium (health) | mg/L as Cr | 0 | - | - |
| Cobalt (health) | ug/L as Co | 0 | - | - |
| Copper (health) | mg/L as Cu | 0 | - | - |
| Cyanide (recoverable) (health) | ug/L as CN- | 0 | - | - |
| Dissolved Organic Carbon (aesthetic/health) | mg/L as C | 0 | - | - |
| Fluoride (health) | mg/L as F- | 0 | - | - |
| Iron (aesthetic/operational) | mg/L as Fe | 0 | - | - |
| Lead (health) | mg/L as Pb | 0 | - | - |
| Magnesium (aesthetic/health) | mg/L as Mg | 0 | - | - |
| Manganese (aesthetic) | mg/L as Mn | 0 | - | - |
| Mercury (health) | mg/L as Hg | 0 | - | - |
| Nickel (health) | ug/L as Ni | 0 | - | - |
| Nitrate (health) | mg/L as N | 0 | - | - |
| Nitrates and Nitrites (health) | mg/L as N | 0 | - | - |


SANS 241 Table C.2: Compliance frequency targets in respect of microbiological and chemical requirements that have health implications

| Quality of Water System | Microbiological requirement | Chemical requirement | |
|-------------------------|-----------------------------|----------------------|----------|
| | Column 5 of Table 1 | Class I | Class II |
| Excellent | >= 99% | >= 95% | >= 97% |
| Good | >= 98% | >= 90% | >= 95% |
| Fair | >= 97% | >= 85% | >= 90% |
| Poor | <97% | <85% | <90% |


Page 23 - Monthly Drinking Water Quality Summary Report for Hantam Municipality




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Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA



SALGA
South African Local Government Association



MESA



WISA

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EDUCATION

Rochester Institute of Technology, Rochester, NY
Masters of Science in Information Technology, May 2009
GPA: 4.0

Lawrence University, Appleton, WI
Bachelor of Arts, June 2007
Majors: Computer Science – Mathematics, Spanish

University of Cape Town, South Africa (Thesis Research, Spring 2009)

University of Granada, Spain (Study Abroad, Fall 2006)

HONORS

Selected by Google to attend the 2008 Workshop for Women Engineers at Google's Headquarter
RIT Graduate Student Scholarship 2007 - 2009
PaeTec student in computing scholarship 2008
XEROX Technical Scholarship 2007
Lawrence University Heritage Scholarship for academic excellence
African Heritage Scholarship for academic & leadership performance
Sigma Alpha Iota Endowment Music Scholarship

RELATED COURSES

| | | |
|-----------------------|-------------------------------------|-----------------------------|
| Usability Engineering | User-Centered Design Methods | Human Computer Interaction, |
| Usability Testing | Graphical Elements of the User Exp. | Interactive Digital Media |

COMPUTER SKILLS & EXPERIENCE

Web Technologies: PHP, XHTML, XML, SQL, Flash, JavaScript, ActionScript 3.0

Other Technologies: Adobe Photoshop, Illustrator, Dreamweaver, iMovie, Morae

Operating Systems: Windows & Macintosh (All Versions), UNIX

- Conducted usability testing on an Emergency Event Reporting System at Uni. of Rochester Medical Center
- Developed a self-service checkout application and interface using user-centered design techniques on a team
- Designed user interfaces for a library navigation system and a social networking tool for companies
 - Created scenarios, user profiles, task analysis, storyboards, prototypes and did design research
- Redesigned a plumbing and remodeling company's website utilizing XHTML, JavaScript and Photoshop
- Utilized Flash to create interactive games and digital media apps (ski game, animated greeting card etc.)

RELATED EXPERIENCE

Business Analyst/App Developer Intern, Chevron Corporation, San Ramon, CA Summer 2008

- Helped to gather requirements and prepare the design document for a Video Conferencing App
- Developed various web applications built in the .NET framework as part of the ITC-GCAS team

Software Engineering Intern, Lockheed Martin, STS, Orlando, FL Summers 2005, 2006, 2007

Virtual Training Systems (VTS) (2007)

- Updated the Training Management System to output student records based on an XML Schema
- Programmed in ADA on a Unix Platform; assisted with functionality testing of tanker simulators

Independent Research & Development (IRAD) Ontology (2006), JSF ALIS (2005)

- Worked in IRAD on the scheduler application (Job Shop) utilizing finite-based constraints to schedule unplanned flight line maintenance actions
- Tested & debugged scheduler; coded in the Oz language in the Mozart Programming System
- Performed software upgrades to the JSF ALIS program's Peer Review Tool
- Wrote the user guide and administration/configuration guide for the Peer Review Tool

Teaching Assistant, Rochester Institute of Technology, Rochester, NY 2007 - 2009

- Assist professor and IT students during undergraduate and graduate digital media classes

Computer Lab Assistant Lawrence University, Appleton, WI 2004 - 2007

- Helped students to create online portfolios using Dreamweaver MX
- Assisted dozens of students with movie editing in iMovie and other computer related issues

Career Assistant, Career Center, Lawrence University, Appleton, WI 2004 - 2006

- Organized and hosted numerous alumni panels and developed strong business rapport with clients
- Reviewed and critiqued over 100 students' resumes and conducted practice interview sessions

OTHER WORK EXPERIENCE

Graduate Assistantship, Study Abroad Office, RIT, Rochester, NY 2007 - 2008

Computer Lab Assistant, Lawrence University, Appleton, WI 2004 - 2007

Student Worker, Information Desk, Lawrence University, Appleton, WI 2005 - 2007

ACTIVITIES

Pre-College Initiative Chair, National Society of Black Engineers (NSBE - RIT Chapter) 2007 - Present

Volunteer Mentor, PALS Program (weekly mentor for an at-risk child) 2004 - 2007

President, PIECE—Privileged Individuals Engaged in Community Enrichment 2004 - 2006

Senior Member, ULEAD (leadership training program) 2003 - 2006